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# **Multi-centre micro-costing of Roux-en-Y gastric bypass, sleeve gastrectomy and adjustable gastric banding procedures for the treatment of severe, complex obesity**

*Short title:* Micro-costing of bariatric surgery

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## **Conflict of Interest**

Richard Welbourn declares receiving support from Ethicon Endo-Surgery for attending conferences and funding a Bariatric Clinical Fellow at their hospital as well as receiving honoraria from Novo Nordisk. Chris A. Rogers received salary funding from the British Heart Foundation. The other authors declare that they have no conflict of interest, except support from a government grant as detailed under funding.

## ABSTRACT

**Background:** There is a growing interest in comparing the effectiveness and costs of alternative forms of bariatric surgery. We aimed to examine the per-patient, procedural costs of Roux-en-Y gastric bypass (RYGB), sleeve gastrectomy (SG) and adjustable gastric banding (AGB) in the United Kingdom.

**Methods:** Multi-centre (two National Health Service; NHS and one private hospital) micro-costing, using a time-and-motion study. Prospective collection of surgery times, staff quantities, equipment, instruments and consumables for 12 patients (four RYGB, five SG, three AGB) from patients' first surgeon interaction on the day of surgery to departure from the theatre recovery area. Costs were attached to quantities and mean costs compared. Sensitivity and scenario analyses assessed the impact of varying surgery inputs and consideration of additional plausible factors respectively on total costs.

**Results:** Mean procedural costs were £5,002 for RYGB, £4,306 for SG and £2,527 for AGB. Varying staff seniority or altering procedure times had small impacts on costs ( $\pm 4\text{-}6\%$ ). Reducing prices of consumables by 20% reduced costs by 10-13%. Accounting for differences in surgical technique by altering the number of staple reloads used impacted costs by  $\pm 7\text{-}10\%$ . Adjusted total costs from scenario analyses were similar to NHS tariffs for RYGB and SG (difference of £51 and -£119 respectively), but were much lower for AGB (difference of £1,982).

**Conclusions:** These detailed costs will allow for more precise reimbursement of bariatric surgery and support comprehensive assessments of cost-effectiveness. Additional work to investigate costs of post-surgical care, re-operations and life-long support received by patients following surgery is required.

## INTRODUCTION

Bariatric surgery is often recommended for individuals with severe and/or complex obesity (body mass index; BMI of  $\geq 40$  kg/m<sup>2</sup> or between 35 kg/m<sup>2</sup> and 40 kg/m<sup>2</sup> with significant co-morbidities).(1-3) Three types of bariatric procedures are mainly used, Roux-en-Y gastric bypass (RYGB), sleeve gastrectomy (SG) and a declining number of adjustable gastric banding (AGB) procedures.(4) Importantly, SG has become an increasingly common procedure, accounting for the majority of surgeries performed in some countries.(5)

Evidence from observational studies suggest that RYGB and SG offer greater weight reduction and improvement of comorbidities, but come with increased risks and less flexibility compared to AGB.(6) However, evidence from comparative randomised controlled trials is limited,(7, 8) as is information on the relative cost-effectiveness of the three procedures.(9, 10) To fill these evidence gaps the By-Band-Sleeve (BBS) randomised controlled trial is being conducted in the UK and is comparing the relative effectiveness and cost-effectiveness of RYGB, SG and AGB.(7, 11) An important part of this trial is to ensure that detailed costs of the three procedures are used in the trial cost-effectiveness analysis.

A recent review (12) identified existing estimates of the procedural costs of RYGB and AGB and noted that many of the analyses failed to consider important cost components (e.g., reporting separate costs for reusable and disposable instruments) and parameters (e.g., accounting for the costs of sterilising reusable instruments) in their estimation. Furthermore, the review did not identify any studies reporting detailed costs for SG. This highlights the need for up-to-date, detailed costings of the three procedures to ensure precise setting of reimbursements, appropriate budgeting by providers and to support comparative assessments of cost-effectiveness.

This paper reports the per-patient procedural costs of RYGB, SG and AGB for the treatment of severe and complex obesity in the National Health Service (NHS) in the UK. We also report procedural costs together with the costs of a pre-operative assessment visit and post-surgery inpatient stay to inform comparisons with NHS tariffs.

## METHODS

### Overview

The procedural costs of bariatric surgery are a function of the resources consumed and their associated unit costs (i.e., the cost for one unit of a particular product or service). The gold standard approach to identifying and valuing resource items is micro-costing (every

input consumed to treat a patient is identified) (13) and bottom-up costing (assigning patient-specific unit costs to each resource item) (14) respectively. Ideally, cost data should also be collected from multiple sites to account for variation in estimates.(15)

A multi-centre micro-costing study was therefore designed, dividing the approach into eight steps (16, 17) (Appendix A) and conducted within the BBS study.(7, 11)

### **Setting, cases for observation and care cycle**

Three hospitals (one private; Site A, and two NHS; Sites B and C) located in the south of England were studied to ensure that variability in costs could be examined.

One consultant surgeon at each of the three sites, who was experienced in each of the three procedures, identified at least three cases (one of each procedure) involving BBS patients 18 years of age or older, scheduled to receive either RYGB, SG or AGB as their first bariatric surgery during 2017.

Micro-costing entails very detailed, costly and labour-intensive data collection, but results in the most accurate representation of costs compared to other costing methods.(13) We therefore aimed to measure the costs of the procedures as accurately as possible, but in a relatively small sample. Our target sample size was nine patients in total; one of each procedure at each of the three sites. Marginally increasing our target sample size (e.g., targeting an additional nine patients) would have necessitated costly investment in data collection with potentially no impact on the external validity of our findings. While greatly increasing our target sample size (e.g., 50-100 patients) would reduce the feasibility of using micro-costing methods, ultimately necessitating the use of less accurate costing methods that could compromise the validity of the study findings. We therefore, judged our target sample size of nine patients to be sufficient to maximise both the internal and external validity of the study findings. It should be noted that there is no minimum accepted sample size for micro-costing studies and sample sizes are usually limited given the trade-off between the cost of collecting additional data and increasing the accuracy and validity of the findings.(18)

The care cycle summarises the boundaries of the costing analysis, in that resource items consumed within the care cycle are used to determine the total cost of each surgical procedure. The care cycle starts from the patient's first interaction with a surgeon on the day of surgery and finishes when the patient leaves the theatre recovery area. The care cycle was chosen to encompass the majority of resource items used during the surgical procedure, but did not include the pre-operative assessment visit or the post-surgery inpatient stay.

## **Patient and operational pathways with resource implications**

The three bariatric procedures were apportioned into pre-operative, intra-operative and post-operative stages (Figure 1) to identify observable patient and operational pathways with resource implications occurring within the care cycle. Resource items consumed within each pathway were identified and broadly grouped into four categories:

- 1) staff (time of consultants/non-consultants, nursing and other allied healthcare professionals);
- 2) theatre (equipment, maintenance and overheads);
- 3) reusable instruments (including sterilisation); and
- 4) consumables (medications, disposables, sutures, etc.).

## **Measuring resource quantities and identifying unit costs**

### *Time-and-motion study*

Direct surgery observation using a time-and-motion study was employed to estimate procedure times, personnel involvement and quantities of resources consumed during the care cycle. One researcher (BD) observed as many of the pathways as possible for each patient and all three procedures were observed at least once, at each of the three sites. As multiple patients were observed on a single day at Sites B and C, it was necessary to devise an algorithm (Appendix B) to ensure all pathways were observed at least once, at each of the three sites, as some of the pathways are overlapping. The algorithm allows the procedure to be observed for all patients, but allocates observations for the remaining seven pathways to individual patients where variation in resources consumed are likely to be minimal.

Observations of the four procedures at Site A were made on three different days, but it was still necessary to follow the algorithm, just across multiple days. Using a stopwatch and standardised data collection form (Appendix C), the observing researcher (BD) recorded the place within the hospital where an activity occurred, the personnel who executed the activity and how much time it took to perform. This allowed for the calculation of the total number of minutes that each type of staff spent providing direct patient care or performing operational activities (e.g., preparation of instrument trays, administrative duties, etc.) (Appendices D and E). The amount and types of medication administered, the number and manufacturer of equipment, re-usable instruments and consumables used within each pathway were also recorded. A summary list of this information is provided in Appendix F.

### *Resource use and cost questionnaire*

To supplement the time-and-motion study, procurement and finance departments at each site were sent a Microsoft Excel 2016 (Microsoft Corporation, Redmond WA) based spreadsheet requesting unit price information for equipment, reusable instruments and consumables recorded during the time-and-motion observations. Information on the life expectancy of equipment, number of operations per year for which the equipment is used, maximum number of uses for reusable instruments, maintenance and repair costs as well as its frequency for equipment was also requested. A separate questionnaire was also sent to personnel in the sterilisation department at each site requesting information on the staff time, equipment and consumables used in the process of sterilising reusable instruments.

### *Cost databases*

Access to the NHS Supply Chain online catalogue and ordering system, which acts as the national provider of equipment, instruments and consumables for approximately 10,000 locations throughout the UK was obtained to identify unit cost information.(19) This database provided national average purchase prices for the majority of reusable instruments and consumables recorded during the surgeries. When required, unit costs were supplemented by site-specific procurement/finance purchase prices collected in the resource use and cost questionnaire. Published national data (e.g., British National Formulary,(20) Personal Social Services Research Unit (PSSRU) Unit Costs of Health and Social Care,(21) Pay and Conditions Circular (22) and Scottish Health Service Costs (23)) were also used as sources of unit costs for medications, staff and theatre time. All unit costs are expressed as 2017 British Pounds Sterling and a summary list of unit costs is provided in Appendix F.

### **Costing models**

Cost models for each procedure and patient were developed in Microsoft Excel 2016 based on equations reported by Ismail *et al.*(24) to calculate the total costs of the four resource categories across all eight pathways.

### *Staff costs*

The per-patient staff costs were estimated as a function of the number of staff involved in a patient's procedure, the total number of minutes worked by each staff member and the cost per working minute for each type of staff. Note that the cost per working minute for each type of staff includes not only a wage/salary, but also banding supplements (applies to registrars/foundation doctors only), employer's national insurance and superannuation

contributions, qualification costs (applies to consultants/registrars only), non-capital overheads (staff training costs, general supplies/services and utilities), capital overheads (office space, recreational and changing facilities) and are adjusted to account for time off due to sickness and training/study.(21)

#### *Theatre costs*

The per-patient theatre costs were estimated by multiplying the total number of minutes for which the theatre was used for a patient's procedure (note this includes four pathways: operating theatre preparation, anaesthesia/patient positioning, procedure and operating theatre cleaning) by a per minute theatre cost derived from the average theatre costs of 15 health boards (total of 375 hospitals) with hours of theatre usage varying from 17 to 2,770 hours/week.(23) This cost includes the purchase prices for furniture, fittings and equipment (non-capital charge), administration and clerical staff costs, cleaning, equipment and property maintenance, utilities, rent and capital charges.(23)

#### *Reusable instrument costs*

The per-patient reusable instruments costs were estimated by adjusting the purchase price of each instrument by its maximum number of uses and associated sterilisation costs (in terms of technician's time and any consumables used in the sterilisation process) and then summing the adjusted costs for each instrument used during the eight pathways.

#### *Consumables costs*

The purchase price for each consumable was divided by the number of units contained within a package to establish a per-unit cost. Multiplying the per-unit cost by the number of units consumed during the procedures resulted in the per-patient cost for each consumable. These costs were then summed for all the consumables used during the eight pathways to estimate the total consumables cost.

#### *Total procedural costs*

Using the costs derived for each resource category, a total per-patient cost estimate for each procedure at each of the three sites was calculated by summing the per-patient costs for staff, theatre, reusable instruments and consumables for each of the eight pathways.

### **Main and sensitivity analyses**

Mean costs for both the four separate resource categories and total procedural costs were estimated for each of the three surgical procedures and variation presented as 95% confidence intervals. Analysis of variance (ANOVA) was used to investigate if there was



significant variation between the mean costs of the three procedures. In the presence of significant variation between the three groups (i.e., ANOVA results with  $p < 0.05$ ), post-hoc paired t-tests (two-tailed) were conducted to determine if the mean costs for two of the procedures were significantly different (i.e., comparisons were made between RYGB versus SG, RYGB versus AGB and SG versus AGB). As multiple comparisons were conducted the Bonferroni correction was applied to compensate for the increased likelihood of a false positive conclusion (i.e., to maintain a 0.05 Type 1 error rate). Statistical significance was assessed at the 0.05 level, but adjusted for three comparisons resulting in a significance threshold of 0.0167.

A number of sensitivity analyses were conducted to assess how the total cost results changed when surgery inputs were varied one parameter at a time. These included, i) varying the levels of staff inputs to account for any differences in the grades/qualifications of staff across sites, ii) altering procedure times (i.e., time from safety checklist to patient leaving theatre) by  $\pm 20\%$ , iii) altering NHS Supply Chain list prices for consumables by  $\pm 20\%$  to account for potential discounts that certain hospitals might receive, iv) altering the estimated cost per minute in the theatre based on minimum and maximum reported values, v) altering the number of staple reloads used during the RYGB and SG procedures to account for the impact of employing different surgical techniques and vi) the use of staple line reinforcement (e.g., seam guards) for the SG procedure. Scenario analyses were also conducted to highlight the impact of considering additional plausible factors not considered in the main analysis that may affect the cost of the procedures. Specifically, NHS Reference Costs (25) were used to calculate the additional costs of a number of different types and potential annual frequencies of outpatient attendances associated with band fills/adjustments, as such events could be considered directly part of the procedure. NHS Reference Costs (25) were also used to calculate the additional costs associated with a pre-operative assessment visit and post-surgery inpatient stay so that the estimates from the main analysis could be directly compared to NHS tariffs.(26)

## **RESULTS**

### **Main analysis**

A breakdown of the total costs by resource category and patient/operational pathway are presented in Figures 2A and 2B respectively. Table 1 presents the per-patient and mean costs overall and for each resource category for the three procedures.

### *Staff costs*

Mean staff costs were largest for RYGB (£1,146; 95% CI £855, £1,438), but were not significantly different ( $p=0.0625$ ) from the mean costs of SG (£769; 95% CI £559, £980) and AGB (£696; 95% CI £562, £829). Site A consistently had the lowest staff costs, except for AGB, where Site B had slightly lower costs (£629 versus £626 respectively). Site C consistently had higher staff costs for all three procedures, with the exception of one RYGB performed at Site B (£1,293 versus £1,493 respectively).

### *Theatre costs*

Mean theatre costs were not significantly different across the three procedures ( $p=0.182$ ), but were slightly larger for RYGB (£711; 95% CI £536, £885) compared to SG (£509; 95% CI £358, £660) and AGB (£489, 95% CI £328, £650). Site A consistently had the lowest and Site C the highest theatre costs across the three procedures. The one exception being one RYGB performed at Site B that had slightly larger costs compared to Site C (£865 versus £831 respectively).

### *Reusable instruments costs*

Mean reusable instruments costs were not significantly different across the three procedures ( $p=0.471$ ) as each site had very similar costs for each of the three procedures. Site C consistently had the highest reusable instruments costs for all three procedures (range £75-£121); whereas Site A had the lowest costs for AGB (£56) and Site B had the lowest costs for RYGB (£71) and SG (£51).

### *Consumables costs*

Mean consumable costs differed significantly across the three procedures ( $p=0.0001$ ). In particular, RYGB (£3,059; 95% CI £2,558, £3,560) and SG (£2,943, 95% CI £2,792, £3,093) costs were each significantly higher than AGB (£1,274, 95% CI £1,112, £1,437) costs ( $p=0.002$  and  $p=0.0001$  respectively), but mean consumables costs for RYGB and SG were similar ( $p=0.643$ ). Variation in the cost of consumables across the three sites for AGB was minimal (range £1,121 to £1,406). Variation was, however, larger for RYGB (range £2,578 to £3,772) and SG (range £2,744 to £3,130).

### *Total procedural costs*

Mean total costs differed significantly across the three procedures ( $p=0.0001$ ). In particular, RYGB (£5,002; 95% CI £4,736, £5,268) and SG (£4,306, 95% CI £3,805, £4,807) costs were each significantly higher than AGB (£2,527, 95% CI £2,138, £2,915) costs

( $p=0.0001$  and  $p=0.003$  respectively), but mean total procedural costs for RYGB and SG were similar ( $p=0.062$ ). Variation in total costs across the three sites for each procedure was largest for SG (range £3,696 to £5,014). The variation in total costs across the three sites for RYGB and AGB was also quite large (ranges £4,721 to £5,280 and £2,158 to £2,838 respectively).

The majority of costs were incurred during the procedure (86%, 84% and 73%) and anaesthesia/patient positioning (9%, 9% and 15%) pathways for RYGB, SG and AGB respectively (Figure 2B), with the remaining pathways contributing only a small proportion to the total procedural costs.

### **Sensitivity analyses**

The results of the sensitivity analyses are presented in Table 2. Increasing the seniority of clinical support staff involved in the procedures to the highest levels observed across the sites and adding a London multiplier (metric used to account for higher salaries in London) to all consultant costs, increased mean total costs by £129, £148 and £202 for AGB, SG and RYGB respectively. Altering the unit costs for all consumables by  $\pm 20\%$  resulted in the largest percentage change in mean total costs for SG ( $\pm£574$ ;  $\pm 13\%$ ), followed by RYGB ( $\pm£594$ ;  $\pm 12\%$ ) and AGB ( $\pm£241$ ;  $\pm 10\%$ ). Using the highest reported per minute theatre cost increased procedural costs by 17-28%, whereas costs decreased by 7-9% when using the lowest per minute theatre cost. Altering procedure times by  $\pm 20\%$  resulted in the largest percentage change in mean total costs for RYGB ( $\pm£285$ ;  $\pm 6\%$ ) and AGB ( $\pm£150$ ;  $\pm 6\%$ ), with SG having a slightly smaller percentage change ( $\pm£171$ ;  $\pm 4\%$ ). Using ten stapler reloads for the RYGB and SG increased procedural costs by 7% and 9% respectively, whereas using only five stapler reloads decreased procedural costs by 9% and 10% respectively. The use of staple line reinforcement had only a small impact on the procedural costs for SG (+3%).

### **Scenario analyses**

The results of the scenario analyses are presented in Tables 3 and 4. Accounting for the additional costs associated with band fills/adjustments increased mean total cost for AGB by between £178 and £940 (+7 to 37%) depending on the type of outpatient attendance (consultant led or non-consultant led), specialty of healthcare professional, number of healthcare professionals involved in the attendance and number of attendances in a year.

Accounting for the additional costs of the pre-operative assessment visit and post-surgery inpatient stay increased total mean procedural costs by 15%, 21% and 23% for

RYGB, SG and AGB respectively. When the NHS 2017/18 tariffs for the procedures were compared to the respective mean adjusted total costs, the tariff was higher by £51 and £1,982 for RYGB and AGB respectively whereas the tariff for SG was £119 less than its mean adjusted total cost.

## DISCUSSION

The mean, per-patient procedural costs from our micro-costing were: £5,002 for RYGB, £4,306 for SG and £2,527 for AGB. Differences in total costs between the three surgical procedures were mainly attributable to differences in the costs of consumables and staff. The between site variation in total procedural costs was largest for SG (range £3,696 to £5,014) followed by AGB (range £2,158 to £2,838) and RYGB (range £4,721 to £5,280). Total procedural costs for SG and AGB were consistently higher at the two NHS hospitals (Sites B and C), whereas the private hospital (Site A) had the second highest cost, behind Site B (NHS hospital) for the RYGB procedure. However, given our limited sample it would be inappropriate to suggest that there might be a difference in the cost of the procedures (particularly SG and AGB) between NHS and private hospitals. Total procedural costs only changed slightly when the surgery inputs were varied in sensitivity analyses, with one exception; using the highest per minute theatre cost increased total procedural costs by 17-28%. In scenario analyses we also highlighted that consideration of the additional costs of a pre-operative assessment visit and the post-surgery inpatient stay resulted in adjusted cost estimates for AGB that were much lower than the NHS tariff, even when also accounting for the additional annual cost of band fills/adjustments (difference range £1,042 to £1,804). In contrast, mean adjusted total costs for RYGB and SG were much closer to their respective tariff (difference of £51 and -£119 respectively). Providing some indication that UK tariffs for the RYGB and SG procedures are reflective of the costs incurred by hospitals to perform the surgeries.

Recently, we conducted a systematic review of analyses reporting detailed breakdowns of the procedural costs of any type of bariatric surgery.<sup>(12)</sup> Compared to costs estimates for either RYGB or AGB reported in the literature (mean US\$14,389 or £10,044) our micro-costing estimates are substantially lower. Differences in the estimates are most likely explained by dissimilar care cycles. However, care cycles in the literature were not clearly defined making it difficult to know over what time frame resource items and costs were measured (e.g., it is not clear if costs prior to the day of surgery or after the post-surgery inpatient stay were included in the existing estimates).

Gounder *et al.*(27) has also reported the cost of RYGB and SG in New Zealand (NZ). Mean operation costs for SG and RYGB were NZ\$9,131 (£4,398) and NZ\$12,456 (£6,001) respectively and included costs for the surgeon, anaesthetist, theatre, ward doctor, ward, pharmacy and radiology/laboratory/pathology costs. The cost of RYGB was 36% higher than the cost of SG. This difference is much larger than observed in our study (cost of RYGB was 16% higher than SG). Gounder *et al.* explain the difference is due to longer procedure times for RYGB compared to SG (230 versus 147 minutes). In our study, the difference in procedure times was much smaller (116 versus 71 minutes), which might explain our smaller difference in mean total costs for the two procedures.

Our study does have limitations. First, our cost estimates are derived from a relatively small number of observations (12 patients). Generally, there is no minimum accepted sample size for micro-costing studies.(18) Given our micro-costing provides a transparent representation of the actual resources utilised during the three procedures across three sites, it was judged that the cost of conducting additional observations outweighed any potential increase in validity. Second, our analysis did not assess the potentially large cost impact of complications (e.g., anastomotic leaks and respiratory failure/infection) resulting in re-admissions within 30-days of the procedure,(28) as the focus of our analysis was specifically on costs incurred during the actual procedure. However, the rates of these events are being recorded in the BBS study and will be an essential aspect of any future economic analysis of bariatric surgery.(29) Third, the availability of site-specific unit cost information was limited, often due to confidentiality concerns. Our analysis therefore relied on purchase prices listed on the NHS Supply Chain online catalogue, which may not reflect prices paid by hospitals capable of negotiating special discounts. Furthermore, aggregated per minute theatre costs were derived from Scottish hospitals and apportioned to the analysis based on the theatre usage attributed to each patient. Despite theatre equipment information being collected during the observations, it was difficult to obtain parameters required to attribute an equipment cost to each procedure and thus the best available estimates were used.

Overall, the results of our study can inform future economic evaluations that compare the relative cost-effectiveness of the three procedures. Such evidence is very limited in the literature (9, 10) and will form a major output of the BBS study. Our methodological approach to costing also provides a framework that can be used by other researchers to estimate detailed procedural costs of bariatric surgery outside the UK because we report our resource items and unit costs separately, therefore other researchers can adjust our figures to

their own setting. This could help facilitate improved estimation of the cost-effectiveness of different approaches to surgery and result in more efficient allocation of limited healthcare resources.

## **COMPLIANCE WITH ETHICAL STANDARDS**

### **Conflict of Interest**

Author 2 declares receiving support from Ethicon Endo-Surgery for attending conferences and funding a Bariatric Clinical Fellow as well as receiving honoraria from Novo Nordisk. Author 5 received salary funding from the British Heart Foundation. All other authors have no conflict of interests to declare, except support from a government grant detailed in the acknowledgements.

### **Ethical Approval**

The National Research Ethics Committee South West – Frenchay approved the micro-costing on 6th December 2011 as part of the BBS study protocol. All procedures performed in studies involving human participants were in accordance with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

### **Informed Consent**

Informed consent was obtained from all individual participants included in the BBS study.

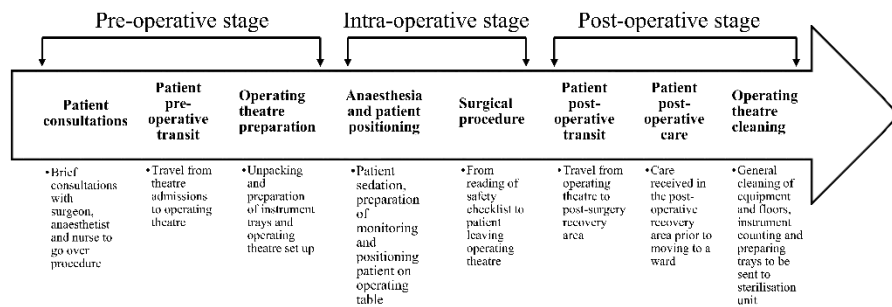
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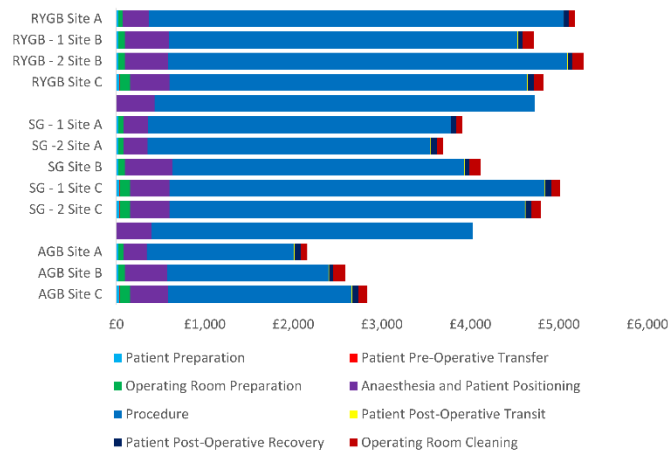


**Figure 1.** Observable patient and operational pathways with resource implications

Resource items consumed within each pathway were identified and broadly grouped into four categories, including staff (time of consultants/non-consultants, nursing and other healthcare professionals), theatre (equipment, maintenance and overheads), reusable instruments (including sterilisation) and consumables (medications, disposables, sutures, etc.).



A



B

**Figure 2.** Breakdown of total procedural costs by (A) resource category and (B) patient/operational pathway

AGB – adjustable gastric banding; RYGB – Roux-en-Y gastric bypass; SG – sleeve gastrectomy

The notation “Site A/B/C – 1/2” is used to denote the observation of multiple patients receiving the same procedure at one site. For example, Site B - 1 refers to the first patient observed at that site receiving RYGB, Site B – 2 refers to the second patient observed at that site receiving RYGB.

Note that Site A is a private healthcare provider and Sites B and C are publicly funded hospitals.

**Table 1.** Per-patient and mean costs by resource category and overall for the three procedures

RYGB		SG		AGB	
Staff costs					
Site A	£856	Site A - 1	£557	Site A	£629
Site B - 1	£944	Site A - 2	£540	Site B	£626
Site B - 2	£1,493	Site B	£738	Site C	£832
Site C	£1,293	Site C - 1	£1,106		
		Site C - 2	£905		
Mean	£1,146		£769		£696
95% CI	£855 to £1,438		£559 to £980		£562 to £829
Theatre costs					
Site A	£475	Site A - 1	£335	Site A	£352
Site B - 1	£670	Site A - 2	£331	Site B	£479
Site B - 2	£865	Site B	£526	Site C	£636
Site C	£831	Site C - 1	£670		
		Site C - 2	£683		
Mean	£711		£509		£489
95% CI	£536 to £885		£358 to £660		£328 to £650
Reusable instrument costs					
Site A	£81	Site A - 1	£81	Site A	£56
Site B - 1	£71	Site A - 2	£81	Site B	£72
Site B - 2	£71	Site B	£51	Site C	£75
Site C	£121	Site C - 1	£107		
		Site C - 2	£107		
Mean	£86		£85		£67
95% CI	£63 to £109		£65 to £106		£56 to £79
Consumables costs					
Site A	£3,772	Site A - 1	£2,934	Site A	£1,121
Site B - 1	£3,035	Site A - 2	£2,744	Site B	£1,406
Site B - 2	£2,850	Site B	£2,804	Site C	£1,295
Site C	£2,578	Site C - 1	£3,130		
		Site C - 2	£3,100		
Mean	£3,059		£2,943		£1,274
95% CI	£2,558 to £3,560		£2,792 to £3,093		£1,112 to £1,437
Total procedural costs					
Site A	£5,184	Site A - 1	£3,907	Site A	£2,158
Site B - 1	£4,721	Site A - 2	£3,696	Site B	£2,583
Site B - 2	£5,280	Site B	£4,119	Site C	£2,838
Site C	£4,823	Site C - 1	£5,014		
		Site C - 2	£4,796		
Mean	£5,002		£4,306		£2,527
95% CI	£4,736 to £5,268		£3,805 to £4,807		£2,138 to £2,915

AGB – adjustable gastric banding; CI – confidence interval; RYGB – Roux-en-Y gastric bypass; SG – sleeve gastrectomy

The notation “Site A/B/C – 1/2” is used to denote the observation of multiple patients receiving the same procedure at one site. For example, Site B - 1 refers to the first patient observed at that site receiving RYGB, whereas Site B – 2 refers to the second patient observed at that site receiving RYGB.

Note that Site A is a private healthcare provider and Sites B and C are publicly-funded hospitals.

**Table 2.** Sensitivity analyses on mean total procedural costs for the three procedures

	<b>RYGB</b>		<b>SG</b>		<b>ABG</b>	
	<b>Mean total cost</b>	<b>Percent change</b>	<b>Mean total cost</b>	<b>Percent change</b>	<b>Mean total cost</b>	<b>Percent change</b>
Main analysis	£5,002	-	£4,306	-	£2,527	-
High staff costs	£5,204	+4%	£4,454	+3%	£2,656	+5%
Low staff costs	£4,742	-5%	£4,134	-4%	£2,373	-6%
+20% consumables cost	£5,596	+12%	£4,880	+13%	£2,768	+10%
-20% consumables cost	£4,408	-12%	£3,732	-13%	£2,285	-10%
High theatre costs	£6,045	+21%	£5,035	+17%	£3,245	+28%
Low theatre costs	£4,664	-7%	£4,034	-6%	£2,294	-9%
+20% procedure time	£5,287	+6%	£4,477	+4%	£2,677	+6%
-20% procedure time	£4,717	-6%	£4,135	-4%	£2,376	-6%
Use of ten stapler reloads <sup>a</sup>	£5,373	+7%	£5,036	+9%	NA	NA
Use of five stapler reloads <sup>a</sup>	£4,529	-9%	£4,152	-10%	NA	NA
Use of staple line reinforcement <sup>b</sup>	NA	NA	£4,414	+3%	NA	NA
No staple line reinforcement <sup>b</sup>	NA	NA	£4,234	-2%	NA	NA

ABG – adjustable gastric banding; RYGB – Roux-en-Y gastric bypass; SG – sleeve gastrectomy

<sup>a</sup>The number of staple reloads that were accounted for in the main analysis for the RYGB procedures included 10 for Site A, 7 and 6 for patient 1 and 2 respectively at Site B and 7 for Site C. The number of staple reloads that were accounted for in the main analysis for the SG procedures included 6 and 5 for patient 1 and 2 respectively for Site A, 5 for Site B and 7 for both patient 1 and 2 for Site C. Please refer to Appendix E for further details.

<sup>b</sup>Only Site C used staple line reinforcement (seam guards) for both patient 1 and 2. Please refer to Appendix F for further details.

**Table 3.** Scenario analyses on the mean total procedural costs for adjustable gastric banding accounting for cost of band fills/adjustments

Type of outpatient attendance for band fill / adjustment	Unit cost of outpatient attendance	Assumed number of outpatient attendances in one year	Total one-year band fill / adjustment cost	Adjusted AGB cost (procedure cost plus one-year band fill/adjustment cost)
<b>Consultant led attendances</b>				
Upper Gastrointestinal Surgery	1 <sup>st</sup> attendance - £171	3	£433	£2,960
	Follow-up attendance - £131	6	£826	£3,353
Multi-professional with Upper Gastrointestinal Surgery lead	1 <sup>st</sup> attendance - £170	3	£478	£3,005
	Follow-up attendance - £154	6	£940	£3,467
Diagnostic Imaging	1 <sup>st</sup> attendance – £50	3	£178	£2,705
	Follow-up attendance - £64	6	£370	£2,897
Multi-professional with Diagnostic Imaging lead	1 <sup>st</sup> attendance - £134	3	£454	£2,981
	Follow-up attendance - £160	6	£934	£3,461
<b>Non-consultant led attendances</b>				
Upper Gastrointestinal Surgery	1 <sup>st</sup> attendance - £112	3	£416	£2,943
	Follow-up attendance - £152	6	£872	£3,399
Multi-professional with Upper Gastrointestinal Surgery lead	1 <sup>st</sup> attendance - £105	3	£333	£2,860
	Follow-up attendance - £114	6	£675	£3,202
Diagnostic Imaging	1 <sup>st</sup> attendance - £31	3	£375	£2,902
	Follow-up attendance - £172	6	£891	£3,418
Multi-professional with Diagnostic Imaging lead	1 <sup>st</sup> attendance - £112	3	£372	£2,899
	Follow-up attendance - £130	6	£762	£3,289

AGB – adjustable gastric banding

Note that band adjustments may be done in the x-ray department by a radiologist, potentially accompanied by a nurse or by a bariatric surgeon and/or bariatric specialist nurse at a clinic appointment. Some adjustments might also be conducted by or with support from a dietician.

Note that the unit costs of non-consultant led follow-up attendances for both ‘Upper Gastrointestinal Surgery’ and ‘Diagnostic Imaging’ specialties are larger than their respective consultant led follow-up attendances. The reason for these counterintuitive differences is not clear, but could potentially be due to a combination of longer attendance times as well as the need for additional supervision of non-consultant led attendances.

**Table 4.** Scenario analyses on the mean total procedural costs for all three procedures accounting for the cost of the pre-operative assessment visit and post-surgery inpatient stay

Lead for surgery	Case	Main analysis mean total cost (A)	Cost of pre-operative assessment <sup>a</sup> (B)	Cost of post-procedure inpatient stay <sup>b</sup> (C)	Adjusted total cost (A+B+C)	NHS 2017/18 tariff <sup>c</sup>	Difference in tariff and adjusted cost
<b>RYGB</b>							
	Site A	£5,184	£141	£615	£5,940	£5,809	-£131
	Site B-1	£4,721	£141	£615	£5,477	£5,809	£332
	Site B-2	£5,280	£141	£615	£6,036	£5,809	-£227
	Site C	£4,823	£141	£615	£5,579	£5,809	£230
	<b>Mean</b>	<b>£5,002</b>	<b>£141</b>	<b>£615</b>	<b>£5,758</b>	<b>£5,809</b>	<b>£51</b>
<b>SG</b>							
	Site A-1	£3,907	£141	£750	£4,798	£5,078	£280
	Site A-2	£3,696	£141	£750	£4,587	£5,078	£491
	Site B	£4,119	£141	£750	£5,010	£5,078	£68
	Site C-1	£5,014	£141	£750	£5,905	£5,078	-£827
	Site C-2	£4,796	£141	£750	£5,687	£5,078	-£609
	<b>Mean</b>	<b>£4,306</b>	<b>£141</b>	<b>£750</b>	<b>£5,197</b>	<b>£5,078</b>	<b>-£119</b>
<b>AGB</b>							
	Site A	£2,158	£141	£428	£2,727	£5,078	£2,351
	Site B	£2,583	£141	£428	£3,152	£5,078	£1,926
	Site C	£2,838	£141	£428	£3,407	£5,078	£1,671
	<b>Mean</b>	<b>£2,527</b>	<b>£141</b>	<b>£428</b>	<b>£3,096</b>	<b>£5,078</b>	<b>£1,982</b>

AGB – adjustable gastric banding; NHS – National Health Service; RYGB – Roux-en-Y gastric bypass; SG – sleeve gastrectomy

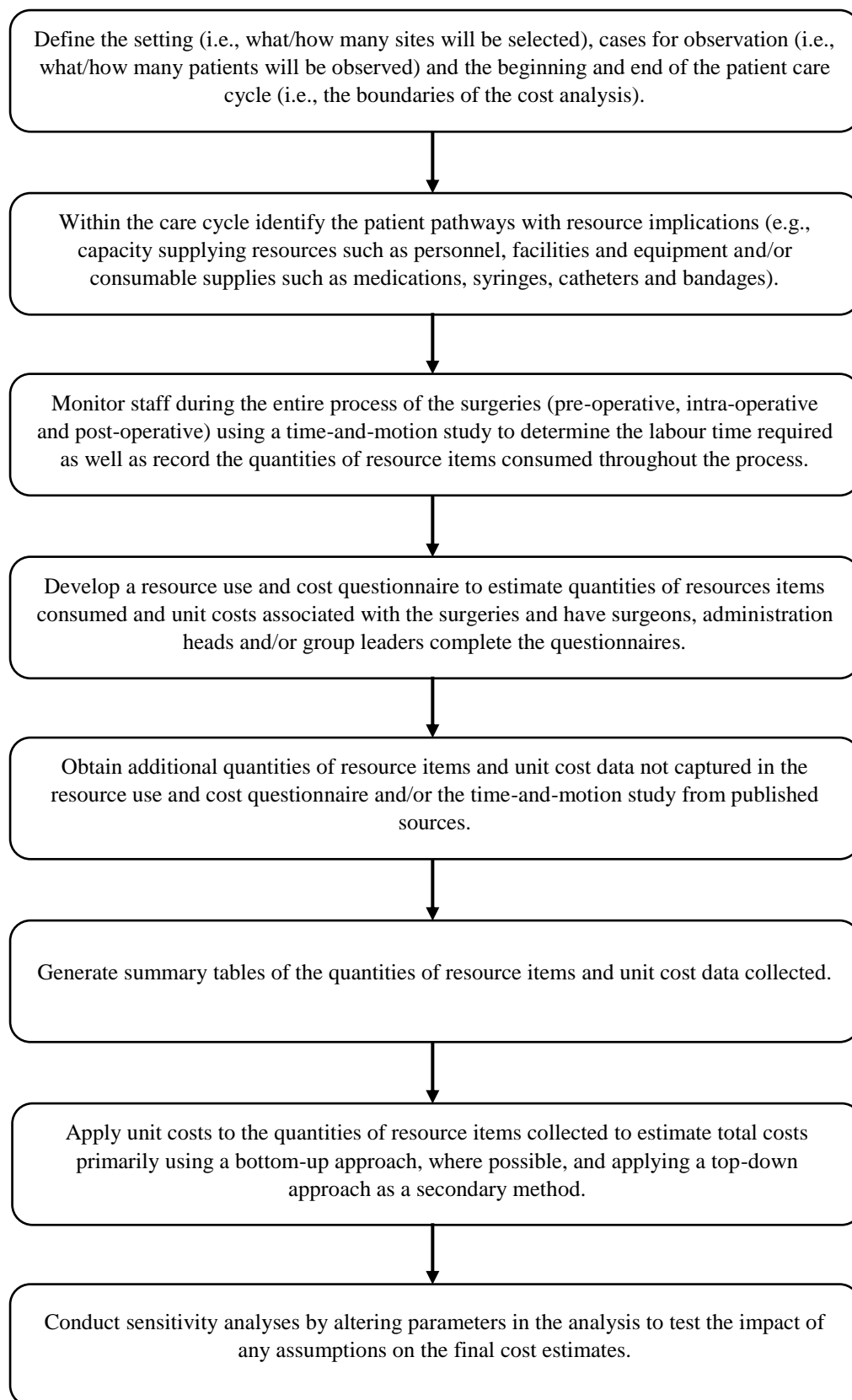
<sup>a</sup>The cost of the pre-operative assessment visit (i.e., update blood tests, electrocardiogram and hospital swabs for methicillin-resistant *Staphylococcus aureus*) were based on the NHS Reference Cost for a consultant-led, general surgery outpatient attendance.

<sup>b</sup>The cost of the post-surgery inpatient stay was derived from the 2016/17 National Schedule of Reference Costs by multiplying the average length of stay in days (note that this is different for each procedure; 2.03 days for gastric bypass, 2.09 days for sleeve gastrectomy and 1.30 days for gastric band) and the excess cost per bed day associated with elective inpatient admissions assigned healthcare resource groups FF11Z “Major Surgical Procedures for Obesity” (£303), FF12Z “Sleeve Gastrectomy for Obesity” (£359) and FF13Z “Gastric Band Procedures for Obesity” (£329) for the gastric bypass, sleeve gastrectomy and adjustable gastric band procedures respectively.

<sup>c</sup>Note that these values represent the national average tariff and have not been adjusted for differences in unavoidable costs between different providers using the Market Forces Factor (compensates providers facing more than the minimum level of unavoidable costs due to geographic location). However, since the mean total costs derived in the main analysis were based mainly on national average unit costs and not site specific unit costs, such an adjustment was unnecessary



## APPENDIX A - STEPS IN CONDUCTING A MICRO-COSTING ANALYSIS



## **APPENDIX B – ALGORITHM USED TO PRIORITISE OBSERVATIONS OF THE EIGHT PATIENT/OPERATIONAL PATHWAYS AT EACH OF THE THREE SITES**

<b>Patient</b>	<b>Patient preparation</b>	<b>Patient pre-operative transit</b>	<b>Operating theatre preparation</b>	<b>Anaesthesia / patient positioning</b>	<b>Procedure</b>	<b>Patient post-operative transit</b>	<b>Patient post-operative care</b>	<b>Operating theatre cleaning</b>
1	Yes	Yes	No	Yes	Yes	Yes	Yes	No
2	No	No	No	No	Yes	No	No	Yes
3	No	No	Yes	Yes	Yes	Yes	Yes	No
4	No	No	No	No	Yes	No	No	Yes
5	No	No	Yes	Yes	Yes	Yes	Yes	No

Note that ‘Yes’ indicates that a observation is to be made for the pathway for the particular patient and ‘No’ indicates that an observation is not to be made for the pathway for the particular patient.

Note that the algorithm was applied separately at each of the three sites. That is, each of the eight patient/operational pathways were observed at least once at each of the three sites. Therefore, the algorithm only considers a sequence of five patients (i.e., the maximum number of patients observed at one site).

## **APPENDIX C – TIME-AND-MOTION DATA COLLECTION FORM**

<b>Date:</b>	<b>Site:</b>	<b>Procedure:</b>	<b>Patient #:</b>
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# **Micro-costing Bariatric Surgery Time-and-Motion Data Collection Form**

**Version 1.0 July 7<sup>th</sup> 2017**







































**APPENDIX D – TOTAL NUMBER OF MINUTES THAT EACH STAFF GROUP  
SPENT PROVIDING CARE OR PERFORMING OPERATIONAL ACTIVITIES  
DURING THE PROCEDURE (TIME FROM SAFETY CHECK TO PATIENT  
LEAVING THE OPERATING THEATRE)**

		Procedure time	Consultant Surgeons	Registrar Surgery	Anaesthetist	Registrar / Trainee Anaesthesiology	Nurses	ODPs	HCA's / HCSWs
RYGB	Site A	75	138	NA	75	NA	135	100	NA
	Site B – 1	104	86	NA	104	104	172	104	143
	Site B – 2	150	130	135	150	150	185	150	270
	Site C	136	118	124	136	NA	260	136	272
SG	Site A – 1	44	74	NA	44	NA	88	44	44
	Site A – 2	43	59	NA	43	NA	41	81	27
	Site B	70	45	45	70	70	140	70	70
	Site C – 1	98	87	76	98	98	196	98	193
	Site C – 2	101	87	87	NA	101	200	101	202
AGB	Site A	48	70	NA	48	NA	96	96	48
	Site B	59	54	54	59	NA	59	59	59
	Site C	89	58	76	89	NA	136	89	136

AGB – adjustable gastric banding; HCA – healthcare assistant; HCSW – healthcare service worker; NA – not applicable; ODP – operating department practitioner; RYGB – Roux-en-Y gastric bypass; SG – sleeve gastrectomy

The notation “Site A/B/C – 1/2” is used to denote the observation of multiple patients receiving the same procedure at one site. For example, Site B - 1 refers to the first patient observed at that site receiving RYGB, whereas Site B – 2 refers to the second patient observed at that site receiving RYGB.

Note that each staff group, except ‘registrar surgery’, ‘anaesthetist’ and ‘registrar/trainee anaesthesiology’, may include more than one staff member. Procedures performed at Site A always involved two consultant surgeons, whereas procedures at the other two sites involved one consultant surgeon accompanied by a registrar (one exception was the RYGB for patient 1 at Site B, where no registrar in surgery was involved). Only the SG for patient 2 at Site A and AGB at Site B involved a single nurse; all other procedures involved two nurses. Only the RYGB, SG for patient 2 and AGB at Site A involved two ODPs; all other procedures involved only one ODP. The three SGs and two AGBs at Sites A and B only involved one HCA/HCSW; all other procedures involved two HCA/HCSW (one exception was the RYGB for Site A, where no HCA/HCSW was involved).

Procedure time refers to the time from performing the safety check in the theatre to the time when the patient leaves the theatre.

Only the RYGB and SG procedures at Site B involved a trainee in anaesthesiology (foundation doctor – year 1). The remaining procedures either involved a registrar in anaesthesiology or no trainee/registrar was involved (denote as NA in the table).

**APPENDIX E – TOTAL NUMBER OF MINUTES THAT EACH STAFF GROUP  
SPENT PROVIDING CARE OR PERFORMING OPERATIONAL ACTIVITIES  
DURING SEVEN OF THE OBSERVED PATHWAYS (EXCLUDES THE  
PROCEDURE)**



		Consultant Surgeons	Registrar Surgery	Anaesthetist	Registrar / Trainee Anaesthesiology	Nurses	ODPs	HCA's / HCSWs	Porters
RYGB	Site A	12	NA	26	NA	99	62	NA	NA
	Site B – 1	6	0	29	25	59	100	89	NA
	Site B – 2	6	2	29	25	59	100	89	NA
	Site C	2	6	31	4	134	31	70	NA
SG	Site A – 1	17	NA	22	NA	112	26	20	3
	Site A – 2	15	NA	21	NA	127	47	20	3
	Site B	6	2	29	25	59	100	89	NA
	Site C – 1	2	6	31	4	134	31	70	NA
	Site C – 2	2	6	31	4	134	31	70	NA
AGB	Site A	15	NA	21	NA	127	47	20	3
	Site B	6	2	29	25	59	100	89	NA
	Site C	2	6	29	4	134	32	70	NA

AGB – adjustable gastric banding; HCA – healthcare assistant; HCSW – healthcare service worker; NA – not applicable; ODP – operating department practitioner; RYGB – Roux-en-Y gastric bypass; SG – sleeve gastrectomy

The notation “Site A/B/C – 1/2” is used to denote the observation of multiple patients receiving the same procedure at one site. For example, Site B - 1 refers to the first patient observed at that site receiving RYGB, whereas Site B – 2 refers to the second patient observed at that site receiving RYGB.

Only the RYGB and SG procedures at Site B involved a trainee in anaesthesiology (foundation doctor – year 1). The remaining procedures either involved a registrar in anaesthesiology or no trainee/registrar was involved (denote as NA in the table).

**APPENDIX F – NUMBER OF RESOURCE ITEMS USED AND ASSOCIATED UNIT  
COSTS FOR STAFF, THEATRE, RE-USABLE INSTRUMENTS AND  
CONSUMABLES**

Resource item	Number of items used	Unit cost	Source of unit cost or other parameter
<b>Staff parameters</b>			
Consultant Surgeon working time	See appendices C and D for staff times	£2.31 / working minute	PSSRU Unit Costs 2017(21) – <b>Consultant: surgical</b> ; cost include wages/salary, salary on-costs, qualifications, overheads and capital overheads.
Anaesthesiologist working time	See appendices C and D for staff times	£2.29 / working minute	PSSRU Unit Costs 2017(21) – <b>Consultant: medical</b> ; cost includes wages/salary, salary on-costs, qualifications, overheads and capital overheads.
Registrar – surgery working time	See appendices C and D for staff times	£1.17 / working minute	PSSRU Unit Costs 2017(21) – <b>Registrar</b> ; cost includes wages/salary, salary on-costs, qualifications, overheads and capital overheads Pay and Conditions Circular (M&D) 1/2016(22) – Average Band 1B Supplement across 10 bands (minimum to 9) based on 48 hour week with moderately antisocial schedule.
Registrar – anaesthesiology working time	See appendices C and D for staff times	£1.17 / working minute	PSSRU Unit Costs 2017(21) – <b>Registrar</b> ; cost includes wages/salary, salary on-costs, qualifications, overheads and capital overheads Pay and Conditions Circular (M&D) 1/2016(22) – Average Band 1B Supplement across 10 bands (minimum to 9) based on 48 hour week with moderately antisocial schedule.
Foundation doctor (FY1) working time	See appendices C and D for staff times	£0.70 / working minute	PSSRU Unit Costs 2017(21) – <b>Foundation doctor FY1</b> ; cost includes wages/salary, salary on-costs, qualifications, overheads and capital overheads Pay and Conditions Circular (M&D) 1/2016(22) – Average Band 1B Supplement across 3 bands (minimum to 2) based on 48 hour week with moderately antisocial schedule.
Nurse (Band 6) patient contact time	See appendices C and D for staff times	£1.83 / minute of	PSSRU Unit Costs 2017(21) – <b>Band 6 Nurse specialist</b> ; cost includes wages/salary on-costs,

Resource item	Number of items used	Unit cost	Source of unit cost or other parameter
		patient contact	overheads and capital overheads; adjusted by the ratio of time spent on patient care to other activities.
Nurse (Band 5) patient contact time	See appendices C and D for staff times	£1.48 / minute of patient contact	PSSRU Unit Costs 2017(21) – <b>Band 5 Nurse</b> ; cost includes wages/salary on-costs, overheads and capital overheads; adjusted by the ratio of time spent on patient care to other activities.
Nurse (Band 6) working time	See appendices C and D for staff times	£0.75 / working minute	PSSRU Unit Costs 2017(21) – <b>Band 6 Nurse specialist</b> ; cost includes wages/salary on-costs, overheads and capital overheads.
Nurse (Band 5) working time	See appendices C and D for staff times	£0.61 / working minute	PSSRU Unit Costs 2017(21) – <b>Band 5 Nurse</b> ; cost includes wages/salary on-costs, overheads and capital overheads.
Nurse (Band 2) working time	See appendices C and D for staff times	£0.36 / working minute	PSSRU Unit Costs 2017(21) – <b>Band 2 Nurse</b> ; cost includes wages/salary on-costs, overheads and capital overheads.
ODP (Band 6) working time	See appendices C and D for staff times	£0.75 / working minute	PSSRU Unit Costs 2017(21) – <b>Band 6 Nurse specialist</b> (assumed to have same unit cost as nurse as no ODP-specific unit cost available); cost includes wages/salary on-costs, overheads and capital overheads.
ODP (Band 5) working time	See appendices C and D for staff times	£0.61 / working minute	PSSRU Unit Costs 2017(21) – <b>Band 5 Nurse</b> (assumed to have same unit cost as nurse as no ODP-specific unit cost available); cost includes wages/salary on-costs, overheads and capital overheads.
ODP (Band 2) working time	See appendices C and D for staff times	£0.37 / working minute	PSSRU Unit Costs 2017(21) – <b>Band 2 Clinical support worker nursing</b> (assumed to have same unit cost as nurse as no ODP-specific unit cost available); cost includes wages/salary, salary on-costs, overheads and capital overheads.

Resource item	Number of items used	Unit cost	Source of unit cost or other parameter		
HSW/HCA (Band 2) working time	See appendices C and D for staff times	£0.37 / working minute	PSSRU Unit Costs 2017(21) – <b>Band 2 Clinical support worker</b> (assumed to have same unit cost as clinical support worker as no HSW/HCA-specific unit cost available); cost includes wages/salary, salary on-costs, overheads and capital overheads.		
Porter (Band 2) working time	See appendices C and D for staff times	£0.37 / working minute	PSSRU Unit Costs 2017(21) – <b>Band 2 Clinical support worker</b> (assumed to have same unit cost as clinical support worker as no porter-specific unit cost available); cost includes wages/salary, salary on-costs, overheads and capital overheads.		
<b><i>Theatre parameters</i></b>					
Site A theatre time; includes operating theatre preparation; anaesthesia/patient positioning; procedure; and operating theatre cleaning	RYGB: 8+18+75+11= <b>112 minutes</b>	£4.24 / minute in theatre	ISD Scotland National Statistics(23) – <b>R140X: Theatre Services (April 2016 – March 2017)</b> ; calculated based on total hours and total allocated costs across 15 boards in Scotland; allocated costs include other staffing costs for clerical and administration, property/equipment maintenance, utilities, rent rates, purchase of furniture, fittings and equipment (non-capital charges) and capital charges.		
	SG – 1: 10+14+44+11= <b>79 minutes</b>				
	SG – 2: 10+14+43+11= <b>78 minutes</b>				
	ABG: 10+14+48+11= <b>83 minutes</b>				
Site B theatre time; includes operating theatre preparation; anaesthesia/patient positioning; procedure; and operating theatre cleaning	RYGB – 1: 14+21+104+19= <b>158 minutes</b>				
	RYGB – 2: 14+21+150+19= <b>204 minutes</b>				
	SG: 14+21+70+19= <b>124 minutes</b>				
	AGB: 14+21+59+19= <b>113 minutes</b>				
Site C theatre time; includes operating theatre preparation; anaesthesia/patient positioning; procedure;	RYGB: 19+23+136+18= <b>196 minutes</b>				
	SG – 1: 19+23+98+18= <b>158 minutes</b>				
	SG – 2: 19+23+101+18= <b>161 minutes</b>				
	AGB: 19+24+89+18= <b>150 minutes</b>				

Resource item	Number of items used	Unit cost	Source of unit cost or other parameter
and operating theatre cleaning			
<b><i>Reusable instruments parameters<sup>a</sup></i></b>			
<b>Instrument Sets – Site A</b>			
Minor Set (RYGB and SG)	29 unique instruments (44 used in total); total purchase price of 29 instruments £494; maximum number of uses 5,280; per instrument sterilisation cost £0.68	Average of £0.68 / instrument use	Purchase price of each instrument was derived from the NHS Supply Chain online catalogue.(19)
Laparoscopy Set (RYGB and SG)	13 unique instruments (24 used in total); total purchase price of 13 instruments £5,641; maximum number of uses 1,320; per instrument sterilisation cost £0.83	Average of £1.16 / instrument use	Purchase price of each instrument was derived from the NHS Supply Chain online catalogue.(19)
Laparoscopy Set (AGB)	14 unique instruments (25 used in total); total purchase price of 14 instruments £5,826; maximum number of uses 1,320; per instrument sterilisation cost £0.80	Average of £1.11 / instrument use	Purchase price of each instrument was derived from the NHS Supply Chain online catalogue.(19)
Laparoscopic Extras (AGB)	17 unique instruments (25 used in total); total purchase price of 17 instruments £223; 5,280; per instrument sterilisation cost £0.80	Average of £0.80 / instrument use	Purchase price of each instrument was derived from the NHS Supply Chain online catalogue.(19)
Thunderbeat Transducer (RYGB and SG)	1 instrument package; total purchase price £0.00; maximum number of uses 1,320; per instrument package sterilisation cost £15.00	£15.00 / instrument package use	Assumption based on information provided by Site C Procurement Department - Provided free of charge when purchasing OLYMPUS Thunderbeat Front-actuated Grip Type S 5mm, 35 cm (Model TB-0535FCS).
Table Poles (RYGB, SG and AGB)	1 instrument package; total purchase price £3,267; maximum number of uses 5,280; per instrument package sterilisation cost £5.00	£5.62 / instrument package use	Purchase price of instrument package was derived from the NHS Supply Chain online catalogue.(19)

Resource item	Number of items used	Unit cost	Source of unit cost or other parameter
Liver Retractor (RYGB, SG and AGB)	1 instrument package; total purchase price £416; maximum number of uses 5,280; per instrument package sterilisation cost £2.50	£2.58 / instrument package use	Purchase price of instrument package was derived from the NHS Supply Chain online catalogue.(19)
<b>Instrument Sets – Site B</b>			
Bariatric Lap Bypass/Banding Tray (RYGB, SG and AGB)	38 unique instruments (60 in total used); total purchase price for 38 instruments £10,614; maximum number of uses 6,240 for 15 instruments and 1,560 for 23 instruments; per instrument sterilisation cost £0.50	Average of £0.68 / instrument use	Purchase price of each instrument was derived from the NHS Supply Chain online catalogue.(19)
Bariatric Fast Clamp (RYGB)	4 unique instruments (4 in total used); total purchase price for 4 instruments £3,153; maximum number of uses 6,240; per instrument sterilisation cost £1.25	Average of £1.38 / instrument use	Purchase price of each instrument was derived from the NHS Supply Chain online catalogue.(19)
Bariatric Martins Arm (SG)	2 unique instruments (2 in total used); total purchase price £3,010; maximum number of uses 6,240; per instrument sterilisation cost £2.50	Average of £2.74 / instrument use	Purchase price of each instrument was derived from the NHS Supply Chain online catalogue.(19)
Sterilisation of Liver Retractor (SG)	3 unique instruments (3 in total used); total purchase price £1,247; maximum number of uses 6,240; per instrument sterilisation cost £0.83	Average of £0.83 / instrument use	Purchase price of each instrument was derived from the NHS Supply Chain online catalogue.(19)
Sterilisation of Endoflex Retractor Straight (RYGB)	2 unique instruments (2 in total used); total purchase price £492; maximum number of uses 1,560; per instrument sterilisation cost £1.25	Average of £1.41 / instrument use	Purchase price of each instrument was derived from the NHS Supply Chain online catalogue.(19)
Mr. Toh Lap Fundo Endoflex (AGB)	9 unique instruments (14 in total used); total purchase price of 9 instruments £3,848; maximum number of uses 1,560; per instrument sterilisation cost £1.43	Average of £1.70 / instrument use	Purchase price of each instrument was derived from the NHS Supply Chain online catalogue.(19)

Resource item	Number of items used	Unit cost	Source of unit cost or other parameter
Light Handles (RYGB, SG and AGB)	3 unique instruments (3 in total used); total purchase price £154; maximum number of uses 1,560; per instrument sterilisation cost £0.83	Average of £0.87 / instrument use	Purchase price of each instrument was derived from the NHS Supply Chain online catalogue.(19)
Bariatric Scope Warmer (RYGB, SG and AGB)	2 unique instruments (2 used in total); total purchase price £229; maximum number of uses 6,240; per instrument sterilisation cost £2.50	Average of £2.52 / instrument use	Purchase price of each instrument was derived from the NHS Supply Chain online catalogue.(19)
HEMO-O-LOK Clip Applicator (RYGB)	1 instrument package; total purchase price £361; maximum number of uses 1,560; per instrument sterilisation cost £15.00	£15.00 / instrument package use	Purchase price of instrument package was derived from the NHS Supply Chain online catalogue.(19)
<b>Instrument Sets – Site C</b>			
Bariatric Basic Set (RYGB and AGB)	13 unique instruments (20 used in total); total purchase price of 13 instruments £178; maximum number of uses 7,920; per instrument sterilisation cost £1.50	Average of £1.50 / instrument use	Purchase price of each instrument was derived from the NHS Supply Chain online catalogue.(19)
Bariatric Set (SG)	29 unique instruments (65 used in total); total purchase price of 29 instruments £410; maximum number of uses 7,920; per instrument sterilisation cost £0.46	Average of £0.46 / instrument use	Purchase price of each instrument was derived from the NHS Supply Chain online catalogue.(19)
Bariatric Laparoscopic Set (SG and AGB)	10 unique instruments (11 used in total); total purchase price of 10 instruments £5,301; maximum number of uses 1,980; per instrument sterilisation cost £1.82	Average of £2.08 / instrument use	Purchase price of each instrument was derived from the NHS Supply Chain online catalogue.(19)
Telescopes (RYGB)	2 unique instruments (2 used in total); total purchase price £2,595; maximum number of uses 1,980; per instrument sterilisation cost £10.00	Average of £10.65 / instrument use	Site C Procurement Department.
Endoscopic Fast Clamp (RYGB, SG and AGB)	4 unique instruments (4 used in total); total purchase price £3,153; maximum	Average of £1.35 /	Purchase price of each instrument was derived from the NHS Supply Chain online catalogue.(19)



Resource item	Number of items used	Unit cost	Source of unit cost or other parameter
	number of uses 7,920; per instrument sterilisation cost £1.25	instrument use	
Microline Clip Applier (RYGB and SG)	2 unique instruments (2 used in total); total purchase price of 2 instruments £0; maximum number of uses 1,980; per instrument sterilisation cost £7.50	Average of £7.50 / instrument use	Site C Procurement Department - Provided free of charge when purchasing MICROLINE SURGICAL M/L-10 Clip Cartridge.
Loan Olymp Trans Purple (RYGB and SG)	1 instrument package; total purchase price £0; maximum number of uses 1,980; per instrument package sterilisation cost £15.00	£15.00 / instrument package use	Site C Procurement Department - Provided free of charge when purchasing OLYMPUS Thunderbeat Front-actuated Grip Type S 5mm, 35 cm (Model TB-0535FCS).
Pinky Trigger (RYGB, SG and AGB)	1 instrument package; total purchase price £2,348; maximum number of uses 1,980; per instrument package sterilisation cost £15.00	£16.18 / instrument package use	Site C Procurement Department.
Liver Retractor (RYGB and SG)	1 instrument package; total purchase price £416; maximum number of uses 7,920; per instrument package sterilisation cost £2.50	£2.55 / instrument package use	Purchase price of instrument package was derived from the NHS Supply Chain online catalogue.(19)
<b>Parameters used to calculate the maximum number of uses for a reusable instrument</b>			
Bariatric surgeries per day	Site A – 6	NA	Site A consultant surgeon estimate
	Site B – 4		Site B consultant surgeon estimate
	Site C - 3		Site C consultant surgeon estimate
Days in a week in which bariatric surgeries are performed	Site A – 1	NA	Site A consultant surgeon estimate
	Site B – 1.5 (1 day 1 <sup>st</sup> week and 2 days 2 <sup>nd</sup> week)		Site B consultant surgeon estimate
	Site C - 3		Site C consultant surgeon estimate
Working weeks per year	Site A – 44	NA	Site A consultant surgeon estimate
	Site B – 52		Site B consultant surgeon estimate
	Site C – 44		Site C consultant surgeon estimate
	Site A – 264	NA	

Resource item	Number of items used	Unit cost	Source of unit cost or other parameter
Bariatric surgeries per year	Site B – 312		Product of bariatric surgeries per day, days in a week in which bariatric surgeries are performed and working weeks per year.
	Site C - 396		
Number of years a reusable instrument is used before it is disposed	Laparoscopic instrument – 5	NA	Assumption
	Non-laparoscopic instrument - 20		Assumption
Maximum number of uses for a reusable instrument	Site A; laparoscopic – 1,320		Product of bariatric surgeries per year and number of years a reusable instrument is used before it is disposed.
	Site A; non-laparoscopic – 5,280		
	Site B; laparoscopic – 1,560		
	Site B; non-laparoscopic – 6,240		
	Site C; laparoscopic – 1,980		
	Site C; non-laparoscopic – 7,920		
Parameters used to calculate per instrument sterilisation cost			
Sterilisation of Minor Set (RYGB and SG – Site A)	44 instruments at a sterilisation cost of £30.00	£0.68 / instrument	Sterile Services Department – Site A
Sterilisation of Laparoscopy Set (RYGB and SG – Site A)	24 instruments at a sterilisation cost of £20.00	£0.83 / instrument	Sterile Services Department – Site A
Sterilisation of Laparoscopy Set (AGB – Site A)	25 instruments at a sterilisation cost of £20.00	£0.80 / instrument	Sterile Services Department – Site A
Sterilisation of Laparoscopy Extras (AGB – Site A)	25 instruments at a sterilisation cost of £20.00	£0.80 / instrument	Sterile Services Department – Site A
Sterilisation of Tables Poles (RYGB, SG and AGB – Site A)	1 instrument package at a sterilisation cost of £5.00	£5.00 / instrument package	Sterile Services Department – Site A
Sterilisation of Liver Retractor (RYGB, SG and AGB – Site A)	1 instrument package at a sterilisation cost of £2.50	£2.50 / instrument package	Sterile Services Department – Site A

<b>Resource item</b>	<b>Number of items used</b>	<b>Unit cost</b>	<b>Source of unit cost or other parameter</b>
Sterilisation of Thunderbeat Transducer (RYGB and SG – Site A)	1 instrument package at a sterilisation cost of £15.00	£15.00 / instrument package	Sterilisation and Sanitation Department – Site A
Sterilisation of Bariatric Lap Bypass/Banding Tray (RYGB, SG and AGB – Site B)	60 instruments at a sterilisation cost of £30.00	£0.50 / instrument	Assumption based on sterilisation costs of Minor Set at Site A
Sterilisation of Bariatric Fast Clamp (RYGB – Site B)	4 instruments at a sterilisation cost of £5.00	£1.25 / instrument	Assumption based on sterilisation costs of Table Poles at Site A
Sterilisation of Bariatric Martins Arm (SG – Site B)	2 instruments at a sterilisation cost of £5.00	£2.50 / instrument	Assumption based on sterilisation costs of Table Poles at Site A
Sterilisation of Liver Retractor (SG – Site B)	3 instruments at a sterilisation cost of £2.50	£0.83 / instrument	Assumption based on sterilisation costs of Liver Retractor at Site A
Sterilisation of Endoflex Retractor Straight (RYGB – Site B)	2 instruments at a sterilisation cost of £2.50	£1.25 / instrument	Assumption based on sterilisation costs of Liver Retractor at Site A
Sterilisation of Mr. Toh Lap Fundo Endoflex (AGB – Site B)	14 instruments at a sterilisation cost of £20.00	£1.43 / instrument	Assumption based on sterilisation costs of Laparoscopy Set at Site A
Sterilisation of Light Handles (RYGB, SG and AGB – Site B)	3 instruments at a sterilisation cost of £2.50	£0.83 / instrument	Assumption based on sterilisation costs of Liver Retractor at Site A
Sterilisation of Bariatric Scope Warmer (RYGB, SG and AGB – Site B)	2 instruments at a sterilisation cost of £5.00	£2.50 / instrument	Assumption based on sterilisation costs of Table Poles at Site A
Sterilisation of HEMO-O-LOK Clip Applicator (RYGB – Site B)	1 instrument package at a sterilisation cost of £15.00	£15.00 / instrument package	Assumption based on sterilisation costs of Thunderbeat Transducer at Site A

Resource item	Number of items used	Unit cost	Source of unit cost or other parameter
Sterilisation of Bariatric Basic Set (RYGB and AGB – Site C)	20 instruments at a sterilisation cost of £30.00	£1.50 / instrument	Assumption based on sterilisation costs of Minor Set at Site A
Sterilisation of Bariatric Set (SG – Site C)	65 instruments at a sterilisation cost of £30.00	£0.46 / instrument	Assumption based on sterilisation costs of Minor Set at Site A
Sterilisation of Bariatric Laparoscopic Set (SG and AGB – Site C)	11 instruments at a sterilisation cost of £20.00	£1.82 / instrument	Assumption based on sterilisation costs of Laparoscopy Set at Site A
Sterilisation of Telescopes (RYGB – Site C)	2 instruments at a sterilisation cost of £20.00	£10.00 / instrument	Assumption based on sterilisation costs of Laparoscopy Set at Site A
Sterilisation of Endoscopic Fast Clamp (RYGB, SG and AGB – Site C)	4 instruments at a sterilisation cost of £5.00	£1.25 / instrument	Assumption based on sterilisation costs of Table Poles at Site A
Sterilisation of Microline Clip Applier (RYGB and SG – Site C)	2 instruments at a sterilisation cost of £15.00	£7.50 / instrument	Assumption based on sterilisation costs of Thunderbeat Transducer at Site A
Sterilisation of Loan Olymp Trans Purple (RYGB and SG – Site C)	1 instrument package at a sterilisation cost of £15.00	£15.00 / instrument package	Assumption based on sterilisation costs of Thunderbeat Transducer at Site A
Sterilisation of Pinky Trigger (RYGB, SG and AGB – Site C)	1 instrument package at a sterilisation cost of £15.00	£15.00 / instrument package	Assumption based on sterilisation costs of Thunderbeat Transducer at Site A
Sterilisation of Liver Retractor (RYGB and SG – Site C)	1 instrument package at a sterilisation cost of £2.50	£2.50 / instrument package	Assumption based on sterilisation costs of Liver Retractor at Site A
<b>Consumables parameters<sup>b</sup></b>			
<b>Site A – RYGB (Main disposable instruments)</b>			
OLYMPUS Thunderbeat 5 mm, 35 cm front-	1	£556.70	NHS Supply Chain (FGE183) Ultrasonic and Advanced Bipolar Energy Tb-0535fc thunderbeat 5

Resource item	Number of items used	Unit cost	Source of unit cost or other parameter
actuated Grip Type S (Model No. TB-0535FCS)			pieces with front-actuated grip; MPC: N4489130; For box of 5 £2783.51 or £556.70 each.(19)
PURPLE SURGICAL 5 mm monopolar scissors; 33 cm	1	£37.70	NHS Supply Chain (FGP607) Scissors Monopolar Ultimate 5mm Monopolar Scissors (33cm); MPC: PS3551ULT; For box of 5 £188.48 or £37.70 each.(19)
APPLIED MEDICAL Kii Fios First Entry 12x100mm; FIOS Obturator with Z-thread sleeve (REF CTF73)	1	£37.11	NHS Supply Chain (FGB663) Trocar 12 x 100mm kii fios first entry threaded; MPC: CTF73; Box of 6 £222.68 or £37.11 each.(19)
APPLIED MEDICAL Kii Sleeve 12x100mm; Z-thread sleeve (REF CTS22)	2	£22.27	NHS Supply Chain (FGB680) Trocar 12 x 150mm kii cannula and seal with z thread; MPC: CTS22; Box of 12 £267.22 or £22.27 each.(19)
APPLIED MEDICAL Kii Fios First Entry 5x100mm; FIOS Obturator with Z-thread sleeve (REF CTF03)	1	£22.27	NHS Supply Chain (FGB666) Trocar 5 x 100mm Kii Fios first entry threaded; MPC: CTF03; Box of 6 £133.61 or £22.27 each.(19)
ETHICON ENDO-SURGERY Echelon flex 60 powered endopathstapler, Articulating endoscopic linear cutter (REF PSE60A)	1	£516.75	NHS Supply Chain (FGE3250) Stapler Linear Powered echelon flex 6 long articulating endoscopic linear cutter instrument does not contain reload; MPC: PLE60A; For Box of 3 £1550.26 or £516.75 each.(19)
ETHICON ENDO-SURGERY Ligaclip 10-M/L 10 mm endoscopic rotating multiple clip	1	£141.74	NHS Supply Chain (FFL115) Ligation clip applier Rotating emca medium/large 10mm diameter; MPC: ER320; For box of 3 £425.22 or £141.74 each.(19)

Resource item	Number of items used	Unit cost	Source of unit cost or other parameter
appliers; contains 20 medium-large titanium clips (REF ER320)			
MICROLINE SURGICAL ReNew Fenestrated grasper tip, disposable (REF 3222-01)	1	£74.23	NHS Supply Chain (FGE2941) Graspers Fenestrated tip disposable; MPC: 3222; Box of 10 £742.27 or £74.23 each.(19)
<b>Site A – RYGB (Staple reloads and sutures)</b>			
Blue monofilament non-absorbable suture (REF W320)	2	£1.37	NHS Supply Chain (FVQ526) Suture non absorbable W320 45cm ethilon non-absorbable monofilament blue 3/0 26mm 3/8 circle reverse cutting needle; MPC: W320; Pack of 12 £16.38 or £1.37 each.(19)
ETHICON PDS II Polydioxanone - 1 V-38; 70cm (REF W9334)	1	£3.94	NHS Supply Chain (FVU383) Suture absorbable W9334T 70cm pds II absorbable monofilament violet 1 30mm tapercut heavy J needle; MPC: W9334T; Pack of 24 £94.56 or £3.94 each.(19)
ETHICON PDS II Polydioxanone - 2-0 SH; 70cm (REF W9125)	1	£2.91	NHS Supply Chain (FVU391) Suture absorbable W9125H 70cm pds II absorbable monofilament violet 2/0 26mm 1/2 circle taper point plus needle; MPC: W9125H; Pack of 36 £104.87 or £2.91 each.(19)
Black braided silk non-absorbable suture (REF W767)	1	£1.66	NHS Supply Chain (FVR552) Suture non absorbable W767 100cm mersilk non-absorbable coated braided black 0 75mm straight conventional cutting needle; MPC: W767; Pack of 12 £19.91 or £1.66 each.(19)
180 Absorbable Polyglyconate Knotless Wound Closure Device (REF VLOCL0615)	2	£28.74	NHS Supply Chain (FVQ1379) Suture v-loc V-Loc 180 2-0 green 30cm V20 X12 barbed; MPC: Vloc10615; Pack of 12 £344.82 or £28.74 each.(19)
90 Glycomer 631 Absorbable Knotless	1	£26.24	NHS Supply Chain (FVQ1636) Suture v-loc V-Loc 90 3-0 violet 15cm V20 X12 barbed; MPC:

Resource item	Number of items used	Unit cost	Source of unit cost or other parameter
Wound Closure Device (REF VLOCM0604)			VLOCM0604; Pack of 12 £314.84 or £26.24 each.(19)
Monofilament Polybutester Nonabsorbable suture (REF 8886445251)	1	£1.12	NHS Supply Chain (FVL1119) Suture novafil Novafil 3-0 blue 75cm V20 X36 monofilament; MPC: 8886445241; Box of 36 £40.48 or £1.12 each.(19)
ETHICON Endopath Echelon Blue Reload 60mm; 3.6mm (REF GST60B)	7	£179.94	NHS Supply Chain (FTX7606) Laparoscopic stapler gst blue reload 60mm 6 row; MPC: GST60B; Box of 12 £2159.26 or £179.94 each.(19)
ETHICON Endopath Echelon White Reload 60mm; 2.6mm (REF GST60W)	3	£179.94	NHS Supply Chain (FTX7605) Laparoscopic stapler gst white reload 60mm 6 row; MPC: GST60W; Box of 12 £2159.26 or £179.94 each.(19)
<b>Site B – RYGB (Main disposable instruments)</b>			
ETHICON Harmonic ACE+7 Laparoscopic Shears 5 mm, 36 mm (REF HARH36) to be used with Generator G11	1 (patient 1); 1 (patient 2)	£578.72	NHS Supply Chain (FGE351) Ultrasonic energy device Harmonic ace plus 7.5mm 36cm; MPC: HARH36; Box of 6 £3472.33 or £578.72 each.(19)
ETHICON Echelon Flex Powered Plus Articulating Endoscopic Linear Cutter 60 mm, 340 mm (REF PSEE60A)	1 (patient 1) ; 1 (patient 2)	£491.88	NHS Supply Chain (FTX7602) Laparoscopic stapler pwr 60 echelon and 340mm shaft; MPC: PSEE60A; Box of 3 £1475.63 or £491.88 each.(19)
APPLIED MEDICAL Epix Laparoscopic Scissors 5 mm x 35 cm (REF CB030)	1 (patient 1); 1 (patient 2)	£24.12	NHS Supply Chain (FGP755) Scissors Laparoscopic Laparoscopic 5mm x 35cm; MPC: CB030; Box of 10 £241.24 or £24.12 each.(19)

Resource item	Number of items used	Unit cost	Source of unit cost or other parameter
ETHICON Endopath Xcel Universal Trocar Stability Sleeve 100 mm, 12 mm (REF 2CB12LT)	2 (patient 1); 1 (patient 2)	£47.75	NHS Supply Chain (FGB854) Trocar bladeless Optiview bladeless; MPC: 2CB12LT; Box of 6 £286.52 or £47.75 each.(19)
ETHICON Endopath Xcel Bladeless Trocar with Stability Sleeve 100 mm, 12 mm (REF 2B12LT)	1 (patient 1); 1 (patient 2)	£107.52	NHS Supply Chain (FGB849) Trocar bladeless Optiview bladeless; MPC: 2B12LT; Box of 6 £645.11 or £107.52 each.(19)
ETHICON Endopath Xcel Universal Trocar Stability Sleeve 100 mm, 5 mm (REF 2CB5LT)	1 (patient 1); 1 (patient 2)	£44.09	NHS Supply Chain (FGE3291) Trocar sleeve Optiview sleeve 5x1mm stability; MPC: 2CB5LT; Box of 6 £264.54 or £44.09 each.(19)
<b>Site B – RYGB (Staple reloads and sutures)</b>			
ETHICON Endopath Echelon Reload White 60 mm, 2.6 mm (REF GST60W)	2 (patient 1); 2 (patient 2)	£179.94	NHS Supply Chain (FTX7605) Laparoscopic stapler gst white reload 60mm 6 row; MPC: GST60W; Box of 12 £2159.26 or £179.94 each.(19)
ETHICON Endopath Echelon Reload Blue 60 mm, 3.6 mm (REF GST60B)	5 (patient 1); 4 (patient 2)	£179.94	NHS Supply Chain (FTX7606) Laparoscopic stapler gst blue reload 60mm 6 row; MPC: GST60B; Box of 12 £2159.26 or £179.94 each.(19)
ETHICON Nylon Tape Polyamide 66 6 mm x 70 cm	1 (patient 1); 0 (patient 2)	£1.27	NHS Supply Chain (FVQ008) Sutures Non Absorbable W277 nylon tape 6mm x 70cm; MPC: W277; Pack of 12 £15.29 or £1.27 each.(19)
ETHICON Monocryl Poliglecaprone 25 3-0, 70 cm (REF W3213)	1 (patient 1); 1 (patient 2)	£3.60	NHS Supply Chain (FVS025) Suture absorbable W3213 70cm monocryl absorbable monofilament undyed 3/0 26mm 3/8 circle reverse cutting prime needle; MPC: W3213; Pack of 12 £43.16 or £3.60 each.(19)



Resource item	Number of items used	Unit cost	Source of unit cost or other parameter
ETHICON Ethibonnd Excel Polyester 2-0, 75 cm (REF W932)	3 (patient 1); 3 (patient 2)	£1.93	NHS Supply Chain (FVT094) Suture non absorbable W932 75cm ethibond excel non-absorbable coated braided green 2/0 31mm 1/2 circle taper point needle; MPC: W932; Pack of 12 £23.17 or £1.93 each.(19)
ETHICON Vicryl Polyglactin 2-0, 75 cm (REF W9136)	1 (patient 1); 1 (patient 2)	£2.26	NHS Supply Chain (FVU509) Suture ansorbable W9136 75cm vicryl absorbable coated braided violet 2/0 31m 1/2 circle taper point plus needle; MPC: W9136; Pack of 12 £27.06 or £2.26 each.(19)
COVIDEN V-Loc 90 Absorbable Wound Closure Device 3-0 15 cm (REF VLOCM0604)	1 (patient 1); 1 (patient 2)	£26.24	NHS Supply Chain (FVQ1636) Suture v-loc V-Loc 90 3-0 violet 15cm V20 X12 barbed; MPC: VLOCM0604; Box of 12 £314.84 or £26.24 each.(19)
ETHICON PDS II Polydioxanone 3-0, 70 cm (REF W9132)	2 (patient 1); 5 (patient 2)	£2.96	NHS Supply Chain (FVU393) Suture absorbable W9132H 70cm pds II absorbable monofilament violet 3/0 31mm 1/2 circle taper point plus needle; MPC: W9132H; Pack of 36 £106.43 or £2.96 each.(19)
<b>Site C – RYGB (Main disposable instruments)</b>			
OLYMPUS Thunderbeat Front-actuated Grip Type S 5 mm, 35 cm (Model TB-0535FCS)	1	£556.70	NHS Supply Chain (FGE4026) Energy accessories tb 0535fcs thunderbeat; MPC: N5423630; Box of 5 £2783.51 or £556.70 each.(19)
ETHICON Endopath ETS-Flex 45 Articulating Endoscopic Linear Cutter 45 mm 340 mm (REF ATS45); has been replaced by Echelon Flex 45 (SC45A)	1	£350.56	NHS Supply Chain (FGS484) Stapler Linear 45 compact articulating endoscopic linear cutter; MPC: SC45A; Box of 3 £1051.68 or £350.56 each.(19)

Resource item	Number of items used	Unit cost	Source of unit cost or other parameter
APPLIED MEDICAL Epix Laparoscopic Scissors 5 mm x 35 cm (REF CB030)	1	£24.12	NHS Supply Chain (FGP755) Scissors Laparoscopic Laparoscopic 5mm x 35cm; MPC: CB030; Box of 10 £241.24 or £24.12 each.(19)
ETHICON Xcel 12 mm ports; has been replaced with Applied Medical Balloon Blunt Trocar (COR47)	3	£37.11	NHS Supply Chain (FGB593) Trocar Kii gelport ballon trocar system 12 x 130mm; MPC: C0R50; Box of 6 £222.68 or £37.11 each.(19)
ETHICON Excel Optiview port (B12LTH)	1	£96.26	NHS Supply Chain (FGB045) Trocar bladeless Bladeless trocar 12mm diameter 100mm length stability sleeve handled; MPC: B12LTH; Box of 6 £577.56 or £96.26 each.(19)
<b>Site C – RYGB (Staple reloads and sutures)</b>			
ETHICON Endopath ETS 45 2.5 mm Reloads White (REF TR45W)	2	£135.23	NHS Supply Chain (FGS155) Stapler Reloads for ETS/ETS Flex Endocutter 45mm white; MPC: TR45W; Box of 12 £1622.75 or £135.23 each.(19)
ETHICON Endopath ETS 45 3.5 mm Reloads Blue (REF 6R45B)	5	£135.23	NHS Supply Chain (FGS408) Loading Unit Stapler Reloads ETS/ETS Flex Endocutter 6 row blue; MPC: 6R45B; Box of 12 £1622.75 or £135.23 each.(19)
MICROLINE SURGICAL M/L-10 Clip Cartridge, 10 Clips Disposable	2	£48.99	NHS Supply Chain (FFL179) Ligation clip applier Viso-Loc disposable 5mm x 20 clips; MPC: 2001; Box of 6 £587.88 or £97.98 each (note divided price by 2 as clips packs used only had 10 clips not 20).(19)
ETHICON Monocryl Poliglecaprone 25 2-0 70 cm (REF W3441)	4	£2.50	NHS Supply Chain (FVS007) Suture absorbable W3441 70cm monocryl absorbable monofilament violet 2/0 31mm 1/2 circle taper point plus needle; MPC: W3441; Pack of 12 £30.03 or £2.50 each.(19)

Resource item	Number of items used	Unit cost	Source of unit cost or other parameter
ETHICON Ethibond Excel Polyester 2-0 75 cm (REF W932)	2	£1.93	NHS Supply Chain (FVT094) Suture non absorbable W932 75cm ethibond excel non-absorbable coated braided green 2/0 31mm 1/2 circle taper point needle.(19)
ETHICON Monocryl Poliglecaprone 25 3-0 45 cm (REF W3207)	1	£3.61	NHS Supply Chain (FVS009) Suture absorbable W3207 45cm monocryl absorbable monofilament undyed 3/0 19mm 3/8 circle reverse cutting prime needle; MPC: W3207; Pack of 12 £43.29 or £3.61 each.(19)
<b>Site A – SG (Main disposable instruments)</b>			
OLYMPUS Thunderbeat 5 mm, 35 cm front-actuated Grip Type S (Model No. TB-0535FCS)	1 (patient 1); 1 (patient 2)	£556.70	NHS Supply Chain (FGE183) Ultrasonic and Advanced Bipolar Energy Tb-0535fc thunderbeat 5 pieces with front-actuated grip; MPC: N4489130; For box of 5 £2783.51 or £556.70 each.(19)
PURPLE SURGICAL 5 mm monopolar scissors; 33 cm	1 (patient 1); 1 (patient 2)	£37.70	NHS Supply Chain (FGP607) Scissors Monopolar Ultimate 5mm Monopolar Scissors (33cm); MPC: PS3551ULT; For box of 5 £188.48 or £37.70 each.(19)
ETHICON ENDO-SURGERY Endopath Xcel Universal Trocar Stability Sleeve; 12 mm	1 (patient 1); 1 (patient 2)	£94.81	NHS Supply Chain (FGB061) Trocar bladeless Bladeless trocar 12 mm diameter 100mm length stability sleeve; MPC: B12LT; For Box of 6 £568.87 or £94.81 each.(19)
ETHICON ENDO-SURGERY Endopath Xcel Dilating Tip Trocar with Stability Sleeve; 12 mm	1 (patient 1); 1 (patient 2)	£75.25	NHS Supply Chain (FGB048) Trocar dilating Tip Dilating tip trocar 12 mm diameter 100mm length stability sleeve; MPC: D12LT; For pack of 6 £451.48 or £75.25 each.(19)
ETHICON ENDO-SURGERY Endopath Xcel Dilating Tip Trocar	1 (patient 1); 1 (patient 2)	£69.70	NHS Supply Chain (FGB047) Trocar dilating Tip Dilating tip trocar 5mm diameter 100mm length stability sleeve; MPC: D5LT; For pack of 6 £418.19 or £69.70 each.(19)

Resource item	Number of items used	Unit cost	Source of unit cost or other parameter
with Stability Sleeve; 5 mm			
ETHICON ENDO-SURGERY Echelon flex 60 powered endopathstapler, Articulating endoscopic linear cutter (REF PSE60A)	1 (patient 1); 1 (patient 2)	£516.75	NHS Supply Chain (FGE3250) Stapler Linear Powered echelon flex 6 long articulating endoscopic linear cutter instrument does not contain reload; MPC: PLE60A; For Box of 3 £1550.26 or £516.75 each.(19)
ETHICON ENDO-SURGERY Ligaclip 10-M/L 10 mm endoscopic rotating multiple clip applicators; contains 20 medium-large titanium clips (REF ER320)	1 (patient 1); 1 (patient 2)	£141.74	NHS Supply Chain (FFL115) Ligation clip applicator Rotating emca medium/large 10mm diameter; MPC: ER320; For box of 3 £425.22 or £141.74 each.(19)
MICROLINE SURGICAL ReNew Fenestrated grasper tip, disposable (REF 3222-01)	1 (patient 1); 1 (patient 2)	£74.23	NHS Supply Chain (FGE2941) Graspers Fenestrated tip disposable; MPC: 3222; Box of 10 £742.27 or £74.23 each.(19)
<b>Site A – SG (Staple reloads and sutures)</b>			
ETHICON Ethilon Polyamide 6 3-0; 45 cm (REF W320)	2 (patient 1); 2 (patient 2)	£1.37	NHS Supply Chain (FVQ526) Suture non absorbable W320 45 cm ethilon non-absorbable monofilament blue 3/0 26 mm 3/8 circle cutting needle; MPC:W320; Pack of 12 for £16.38 or £1.37 each.(19)
ETHICON PDS II Polycloxanone 70 cm (REF W9334)	2 (patient 1); 1 (patient 2)	£3.94	NHS Supply Chain (FVU383) Suture absorbable W9334T 70 cm pds II absorbable monofilament violet 1 30 mm tapercut heavy J needle; MPC: W9334T; Pack of 24 for £94.56 or £3.94 each.(19)

Resource item	Number of items used	Unit cost	Source of unit cost or other parameter
ETHICON Mersilk Soie 100 cm (REF W767)	1 (patient 1); 1 (patient 2)	£1.66	NHS Supply Chain (FVR552) Suture non absorbable W767 100cm mersilk non-absorbable coated braided black 0 75mm straight conventional cutting needle; MPC: W767; Pack of 12 for £19.91 or £1.66 each.(19)
ETHICON Endopath Echelon Reload 60 mm Green 4.1 mm 6 rows (REF GST60G)	2 (patient 1); 1 (patient 2)	£179.94	NHS Supply Chain (FTX7608) Laparoscopic stapler gst green reload 60mm 6 row; MPC: GST60G; For box of 12 £2159.26 or £179.94 each.(19)
ETHICON Endopath Echelon Reload 60 mm Gold 3.8 mm 6 rows (REF GST60D)	3 (patient 1); 2 (patient 2)	£179.94	NHS Supply Chain (FTX7607) Laparoscopic stapler gst gold reload 60mm 6 row; MPC: GST60D; For box of 12 £2159.26 or £179.94 each.(19)
ETHICON Endopath Echelon Reload 60 mm Blue 3.6 mm 6 rows (REF GST60B)	1 (patient 1); 2 (patient 2)	£179.94	NHS Supply Chain (FTX7606) Laparoscopic stapler gst blue reload 60mm 6 row; MPC: GST60B; For box of 12 £2159.26 or £179.94 each.(19)
<b>Site B – SG (Main disposable instruments)</b>			
ETHICON Echelon Flex Powered Plus Articulating Endoscopic Linear Cutter 60 mm, 340 mm (REF PSEEGOA)	1	£516.75	NHS Supply Chain (FGE3250) Stapler Linear Powered echelon flex 6 lon articulating endoscopic linear cutter instrument does not contain a reload; MPC: PLE60A; Box of 3 £1550.26 or £516.75 each.(19)
ETHICON Harmonic ACE +7 Laparoscopic Shears 5 mm 36 cm shaft (REF HARH36), to be used with Generator G11	1	£578.72	NHS Supply Chain (FGE351) Ultrasonic energy device Harmonic ace plus 7.5mm 36cm; MPC: HARH36; Box of 6 £3472.33 or £578.72 each.(19)
ETHICON Endopath Xcel Universal Trocar Stability	3	£47.75	NHS Supply Chain (FGB854) Trocar bladeless Optiview bladeless; MPC: 2CB12LT; Box of 6 £286.52 or £47.75 each.(19)

Resource item	Number of items used	Unit cost	Source of unit cost or other parameter
Sleeve 100 mm (REF 2CB12LT)			
ETHICON Endopath Xcel Bladeless Trocar with Stability Sleeve 100 mm (REF 2B5LT)	2	£100.94	NHS Supply Chain (FGE3261) Trocar bladeless Optiview bladeless 5x1 stability; MPC: 2B5LT; Box of 6 £605.62 or £100.94 each.(19)
APPLIED MEDICAL Epix Laparoscopic scissors 5mm x 35 cm (REF CB030)	1	£24.12	NHS Supply Chain (FGP755) Scissors Laparoscopic Laparoscopic 5mm x 35cm; MPC: CB030; Box of 10 £241.24 or £24.12 each.(19)
<b>Site B – SG (Staple reloads and sutures)</b>			
ETHICON Endopath Echelon Reload Gold 60 mm 3.8 mm (REF GST60D)	2	£179.94	NHS Supply Chain (FTX7607) Laparoscopic stapler gst gold reload 60mm 6 row; MPC: GST60D; Box of 12 £2159.26 or £179.94 each.(19)
ETHICON Endopath Echelon Reload Blue 60 mm 3.6 mm (REF GST60B)	3	£179.94	NHS Supply Chain (FTX7606) Laparoscopic stapler gst blue reload 60mm 6 row; MPC: GST60B; Box of 12 £2159.26 or £179.94 each.(19)
ETHICON PDS II Polydioxanone 3-0 70 cm	1	£4.06	NHS Supply Chain (FVS1072) Suture PDS II 70cm Absorbable Monofilament Violet 3/0 31mm 1/2 Circle Ethiguard Needle; MPC: W9958H; Box of 36 £146.25 or £4.06 each.(19)
ETHICON Monocryl 3-0 70 cm	1	£3.60	NHS Supply Chain (FVS025) Suture absorbable W3213 70cm monocryl absorbable monofilament undyed 3/0 26mm 3/8 circle reverse cutting prime needle; MPC: W3213; Pack of 12 £43.16 or £3.60 each.(19)
ETHICON PDS II Polydioxanone 0 150 cm (REF W9966)	1	£6.37	NHS Supply Chain (FVU124) Suture absorbable W9966T 150cm pds II absorbable monofilament violet 0 50mm 1/2 circle ethiguard heavy needle

Resource item	Number of items used	Unit cost	Source of unit cost or other parameter
			loop; MPC: W9966T; Pack of 24 £152.87 or £6.37 each.(19)
<b>Site C – SG (Main disposable instruments)</b>			
OLYMPUS Thunderbeat Front-actuated Grip Type S 5 mm, 35 cm (Model TB-0535FCS)	1 (patient 1); 1 (patient 2)	£556.70	NHS Supply Chain (FGE4026) Energy accessories tb 0535fcs thunderbeat; MPC:N5423630; Box of 5 £2783.51 or £556.70 each.(19)
ETHICON Echelon Flex 60 Stapler Articulating Endoscopic Linear Cutter 60 mm 340 mm	1 (patient 1); 1 (patient 2)	£516.75	NHS Supply Chain (FGE3250) Stapler Linear Powered echelon flex 6 long articulating endoscopic linear cutter instrument does not contain a reload; MPC: PLE60A; Box of 3 £1550.26 or £516.75 each.(19)
ETHICON Xcel 12 mm ports; has been replaced with Applied Medical Balloon Blunt Trocar (COR47)	3 (patient 1); 3 (patient 2)	£37.11	NHS Supply Chain (FGB593) Trocar Kii gelport ballon trocar system 12 x 130mm; MPC: C0R50; Box of 6 £222.68 or £37.11 each.(19)
ETHICON Excel Optiview port (B12LTH)	1 (patient 1); 1 (patient 2)	£96.26	NHS Supply Chain (FGB045) Trocar bladeless Bladeless trocar 12mm diameter 100mm length stability sleeve handled; MPC: B12LTH; Box of 6 £577.56 or £96.26 each.(19)
<b>Site C – SG (Staple reloads and sutures)</b>			
ETHICON Echelon 60 Reloads Green 4.1 mm (REF ECR60G)	7 (patient 1); 6 (patient 2)	£163.63	NHS Supply Chain (FGS406) Loading Unit Stapler Reload for Echelon 60 green; MPC: ECR60G; Box of 12 £1963.60 or £163.63 each.(19)
ETHICON Echelon 60 Reloads Black 4.2 mm (REF GST60T)	0 (patient 1); 1 (patient 2)	£179.94	NHS Supply Chain (FTX7609) Laparoscopic stapler gst black reload 60mm 6 row; MPC: GST60T; Box of 12 £2159.26 or £179.94 each.(19)
GORE Seamguard Bioabsorbable Staple Line	2 (patient 1); 2 (patient 2)	£90.00	Site C Procurement Department.

Resource item	Number of items used	Unit cost	Source of unit cost or other parameter
Reinforcement (REF BSGEC60AC)			
ETHICON Monocryl Poliglecaprone 25 3-0 45 cm (REF W3207)	1 (patient 1); 2 (patient 2)	£3.61	NHS Supply Chain (FVS009) Suture absorbable W3207 45cm monocryl absorbable monofilament undyed 3/0 19mm 3/8 circle reverse cutting prime needle; MPC: W3207; Pack of 12 £43.29 or £3.61 each.(19)
ETHICON PDS II Polydioxanone 0, 70 cm (REF W9333)	1 (patient 1); 0 (patient 2)	£3.79	NHS Supply Chain (FVU382) Suture absorbable W9333T 70cm pds II absorbable monofilament violet 0 30mm J needle J tapercut heavy needle; MPC: W9333T; Pack of 24 £91.00 or £3.79 each.(19)
ETHICON Vicryl Polyglactin 910 1, 75 cm (REF W9245)	0 (patient 1); 1 (patient 2)	£2.72	NHS Supply Chain (FVU511) Suture absorbable W9245 75cm vicryl absorbable coated braided violet 1 45mm 1/2 circle taper point heavy needle; MPC: W9245; Pack of 12 £32.62 or £2.72 each.(19)
MICROLINE SURGICAL M/L-10 Clip Cartridge, 10 Clips Disposable	3 (patient 1); 2 (patient 2)	£48.99	NHS Supply Chain (FFL179) Ligation clip applicator Viso-Loc disposable 5mm x 20 clips; MPC: 2001; Box of 6 £587.88 or £97.98 each (note divided price by 2 as clips packs used only had 10 clips not 20).(19)
<b>Site A – AGB (Main disposable instruments and banding device)</b>			
APOLLO ENDOSURGERY Lap-Band AP System AP Small Rapid Port EZ (REF C-20360)	1	£714.50	Site C Procurement Department.
Monopolar electrode L Hook (PS3881)	1	£13.49	NHS Supply Chain (EHC2243) General Laparoscopy Pack 5mm/33cm monopolar electrode L hook set; MPC: PS3881; Box of 5 £67.44 or £13.49 each.(19)



Resource item	Number of items used	Unit cost	Source of unit cost or other parameter
Straight grasping forceps (PS4553)	1	£32.81	NHS Supply Chain (EHC2252) General Laparoscopy Pack Essential 5mm straight grasping forceps 33cm set; MPC: PS4553; Box of 5 or £32.81 each.(19)
Trocar 5 x 100mm (CTS02)	1	£12.37	NHS Supply Chain (FGB682) Trocar 5 x 100mm kii cannula and seal with z thread; MPC: CTS02; Box of 12 for £148.45 or £12.37 each.(19)
Trocar 5 x 100mm (CTF03)	1	£22.27	NHS Supply Chain (FGB666) Trocar 5 x 100mm Kii Fios first entry threaded; MPC: CTF03; Box of 6 for £133.61 or £22.27 each.(19)
Trocar 12 x 150mm (CTS22)	1	£22.27	NHS Supply Chain (FGB680) Trocar 12 x 150mm kii cannula and seal with z thread; MPC: CTS22; Box of 12 £267.22 or £22.27 each.(19)
Trocar bladed 12mm x 100mm (CTB73)	1	£37.11	NHS Supply Chain (FGB676) Trocar bladed 12mm x 100mm kii shielded bladed access with z thread; MPC: CTB73; Box of 6 £222.68 or £37.11 each.(19)
<b>Site A – AGB (Sutures)</b>			
Green suture non absorbable (W969)	2	£1.97	NHS Supply Chain (FVS314) Suture non absorbable W969 75cm ethibond excel non-absorbable coated braided green 1 31mm taper point heavy J needle; MPC: W969; Pack of 12 £23.66 or £1.97 each.(19)
Monofilament Polybutester Nonabsorbable suture (REF 8886445251)	3	£1.12	NHS Supply Chain (FVL1119) Suture novafil Novafil 3-0 blue 75cm V20 X36 monofilament; MPC: 8886445241; Box of 36 £40.48 or £1.12 each.(19)
<b>Site B – AGB (Main disposable instruments and banding device)</b>			
APOLLO ENDOSURGERY Lap-Band AP System AP Small Rapid Port EZ (REF C-20360)	1	£714.50	Site C Procurement Department.

Resource item	Number of items used	Unit cost	Source of unit cost or other parameter
APPLIED MEDICAL Kii Shielded Bladed Dual Pack 5 x 100 mm (REF CTB12)	2	£27.22	NHS Supply Chain (FGB679) Trocar bladed 5mm x 100mm kii shielded bladed access system with z thread; MPC: CTB12; Box of 10 £272.17 or £27.22 each.(19)
ETHICON Endopath Xcel Bladeless Trocar with Stability Sleeve 100 mm, 12 mm (REF 2B12LT)	1	£107.52	NHS Supply Chain (FGB849) Trocar bladeless Optiview bladeless; MPC: 2B12LT; Box of 6 £645.11 or £107.52 each.(19)
ETHICON Endopath Xcel Bladeless Trocar with Stability Sleeve 100 mm, 15 mm (B15LT)	1	£97.72	NHS Supply Chain (FGB293) Trocar bladeless 15mm diameter 100mm length stability sleeve; MPC: B15LT; Box of 6 £586.32 or £97.72 each.(19)
<b>Site B – AGB (Sutures)</b>			
Green coated braided non-absorbable suture (REF W969)	3	£1.97	NHS Supply Chain (FVS314) Suture non absorbable W969 75cm ethibond excel non-absorbable coated braided green 1 31mm taper point heavy J needle; MPC: W969; Pack of 12 £23.66 or £1.97 each.(19)
ETHICON Monocryl 3-0, 70 cm (REF W3213)	2	£3.60	NHS Supply Chain (FVS025) Suture absorbable W3213 70cm monocryl absorbable monofilament undyed 3/0 26mm 3/8 circle reverse cutting prime needle; MPC: W3213; Pack of 12 £43.16 or £3.60 each.(19)
<b>Site C – AGB (Main disposable instruments and banding device)</b>			
Apollo ENDOSURGERY LAP-BAND AP Adjustable Gastric Banding System with RapidPort EZ and OMNIFORM Design; Size AP Large (REF C-20365)	1	£714.50	Site C Procurement Department.

Resource item	Number of items used	Unit cost	Source of unit cost or other parameter
ETHICON Xcel 12 mm ports; has been replaced with Applied Medical Balloon Blunt Trocar (COR47)	3	£37.11	NHS Supply Chain (FGB593) Trocar Kii gelport ballon trocar system 12 x 130mm; MPC: C0R50; Box of 6 £222.68 or £37.11 each.(19)
ETHICON Excel Optiview port (B12LTH)	1	£96.26	NHS Supply Chain (FGB045) Trocar bladeless Bladeless trocar 12mm diameter 100mm length stability sleeve handled; MPC: B12LTH; Box of 6 £577.56 or £96.26 each.(19)
<b>Site C – AGB (Sutures)</b>			
ETHICON Ethibond Excel Polyester 1 45 cm	2	£1.77	NHS Supply Chain (FKV9840) Sutures Non Absorbable green 45cm m3 gauge 2 0 to 2; MPC: 6664H; Box of 36 £63.64 or £1.77 each.(19)
ETHICON Ethibond Excel Polyester 2-0 75 cm (REF W932)	2	£1.93	NHS Supply Chain (FVT094) Suture non-absorbable W932 75cm ethibond excel non-absorbable coated braided green 2/0 31mm 1/2 circle taper point needle; MPC: W932; Pack of 12 £23.17 or £1.93 each.(19)
ETHICON Monocryl Poliglecaprone 25 3-0 45 cm (REF W3207)	1	£3.61	NHS Supply Chain (FVS009) Suture absorbable W3207 45cm monocryl absorbable monofilament undyed 3/0 19mm 3/8 circle reverse cutting prime needle; MPC: W3207; Pack of 12 £43.29 or £3.61 each.(19)

AGB – adjustable gastric banding; HCA – healthcare assistant; HCSW – healthcare service worker; NA – not applicable; ODP – operating department practitioner; RYGB – Roux-en-Y gastric bypass; SG – sleeve gastrectomy

<sup>a</sup>For brevity, details are only provided for the main reusable instrument sets and parameters use to calculate unit costs for each instrument contained in the sets; complete details of the reusable instruments used for each of the three procedures at all three sites are available from the authors on request.

<sup>b</sup>For brevity, details are only provided for the main consumables (e.g., main disposable instruments, staple reloads and sutures); complete details of the consumables used for each of the three procedures at all three sites are available from the authors on request